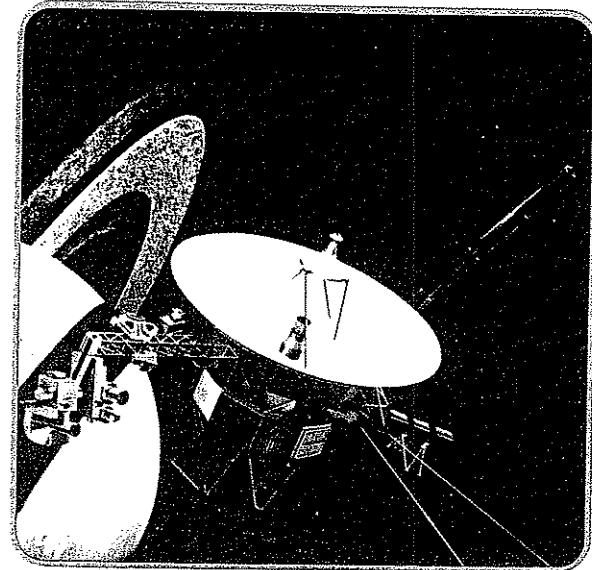


Earth Science Workshop 3



UNDERSTANDING SPACE

SEYMOUR ROSEN



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CONTENTS

1	Why do we study outer space?	1
2	What is a telescope?	7
3	What is a spectroscope?	13
4	What are stars like?	19
5	How far away are the stars?	25
6	How do we measure star distance?	29
7	What are galaxies and constellations?	35
8	What is the solar system?	39
9	Why is the sun important?	45
10	How does the sun get its energy?	51
11	What are the earth's motions?	57
12	What is the shape of the earth's orbit?	61
13	How do we know that the earth is rotating?	67
14	What causes day and night?	73
15	What causes the seasons?	81
16	Why is the time different around the world?	87

17	What is gravity?	95
18	Why can we see only one side of the moon?	101
19	Why does the moon seem to change shape?	109
20	What is a solar eclipse?	115
21	What is a lunar eclipse?	123
22	What causes tides?	129
23	Why do heavenly bodies keep moving?	137
24	What causes a rocket to move through space?	141
25	How does a satellite go into orbit?	147
26	How does a spacecraft reach the moon?	155
27	How do we solve the problems of living in space?	163
Keeping Up With Science		
	Diamonds in the Sky	12
	Visitors with Long Shining Tails	66
	A Message from Venus	114

BEFORE YOU BEGIN . . .

An Earthling in a white space suit steps out of the spacecraft. The ground below shows the imprint of a heavy boot—the only sign of life in this cold and distant place.

Science fiction? No, of course not. Several astronauts have walked on the moon. Still others have lived in outer space for months.

Space travel is just part of what you will learn about in this book. You will also learn about the motions of the moon, earth, and other planets. This book describes what instruments are used by scientists to study the distant stars.

Why do we have seasons? Why does night become day? These questions are answered in this book, too.

Earth Science Workshop 3 is divided into 27 Aims. Each Aim starts with the information you'll need to know. This is followed by a series of exercises. Take your time on these. Look back to the beginning of the Aim whenever you're not sure of an answer. You'll find experiments and word games to do in the Aims, too.

SCIENCE SAFETY

Science is the study of the world around you. The study of any branch of science includes "learning by doing." Investigations, experiments, demonstrations. Activities in which you are involved. You make things happen.

Safety is a very important part of these activities. Even if you are only reading about an investigation, you should know about the safety precautions that **MUST** be taken. The following **SAFETY ALERT SYMBOLS** are designed to call these precautions to your attention. They appear on pages wherever any of these dangers are present.



Safety Goggles



Lab Apron
or Coat

Safety goggles and a laboratory apron or coat should be worn for all activities or investigations.



Open Flame

When working near an open flame, be sure that hair and loose clothing are secured in some manner.



Poison

Many chemicals are poisonous, or toxic. *Never* taste, touch, or smell any unknown substance unless told to do so by your teacher.



Caustic Substances

Caustic (KAW stik) substances can burn your skin, eyes, and clothing. Handle these substances with extreme care. Acids and bases (such as lye) are caustic.



Toxic Vapors

Never inhale any vapors directly. To test the odor of a substance, use your hand to waft the vapors to your nose.



Sharp Objects

Always handle sharp objects with great care.



Broken Glass

Glassware, such as beakers, test tubes, glass tubing, and thermometers should be handled very carefully to avoid breakage. *Never* pick up broken glass with your bare hands.



Electric Shock

Never use electrical appliances near water or other liquids. Always inspect wiring for worn or broken insulation. Unplug all electric cords when not in use.

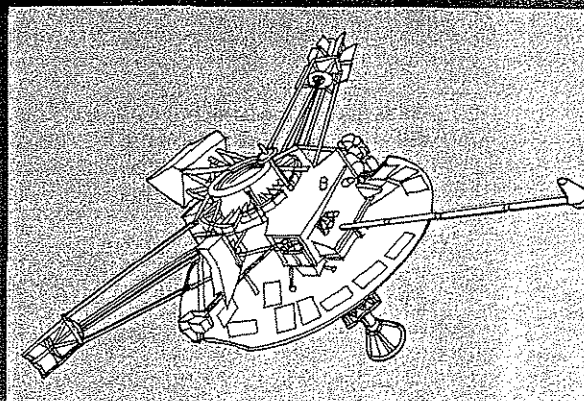


Hot Objects

When handling hot objects, use tongs or padded gloves. *Never* set hot objects directly on a desk or table top. Set them on a heat-resistant pad.

WHY DO WE STUDY OUTER SPACE?

1





astronomy: the study of heavenly bodies

satellite: an object in space that moves around another

AIM | Why do we study outer space?

1

Did you know that "outer space" is part of the universe (YOON uh vurs)? Our planet—Earth—is also part of the universe. A very thin part! In fact, everything that exists is part of the universe! So, when we study outer space, we are learning more about OUR universe.

Did you ever look deep into an evening sky? Did you wonder how far away the stars are and what lies beyond the stars?

People have always wondered about the heavens. Early people did not understand the nature of the stars or the sun. They did not know why the moon seems to change shape. They did not understand about flashing meteors or eclipses that blotted out the sun.

This lack of understanding led to fear. In fact, many early people worshiped heavenly bodies because they were afraid.

Time passed. People started to have different ideas about the heavens. They had less fear. But still, they had little real understanding. As late as the mid-1500's, most people believed that the earth was the center of the universe. They thought that the sun, planets, and all the stars moved around the earth.

Today, we know that this is not true. We know that the earth is just a tiny speck in a huge universe. And the universe seems to go on . . . and on. It reaches deeper and deeper into space. It seems to have no end.

Now let's "get back to Earth!" Why do we study outer space?

The answer lies in the nature of the human mind. We see the heavens. We ask questions. And we look for answers. We have found many answers. But many more questions yet remain.

When we learn more about outer space, we understand the universe a little better. From this understanding, we also understand Earth's place in the universe a little better.

ABOUT ASTRONOMY

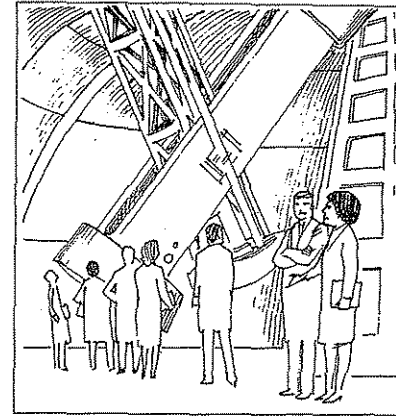


Figure A

The study of heavenly bodies is called *astronomy* (uh STRON uh mee).

A scientist who studies astronomy is called an *astronomer*.

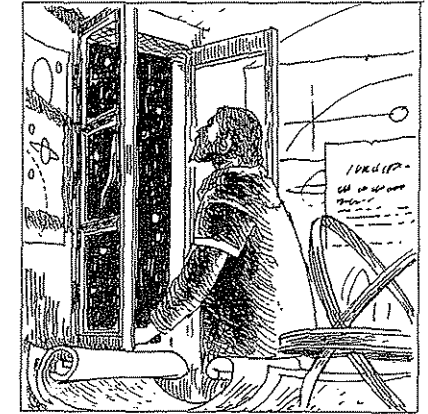


Figure B

Nicholas Copernicus (ko PUR ni kus) was an important early astronomer (1473–1543). He was the first to show that the earth was **not** the center of the universe. He made accurate observations of the sky **without** the help of instruments.

By observing the sky, astronomers have found that heavenly bodies often move around one another. Any object in space that moves around another object is called a *satellite*.

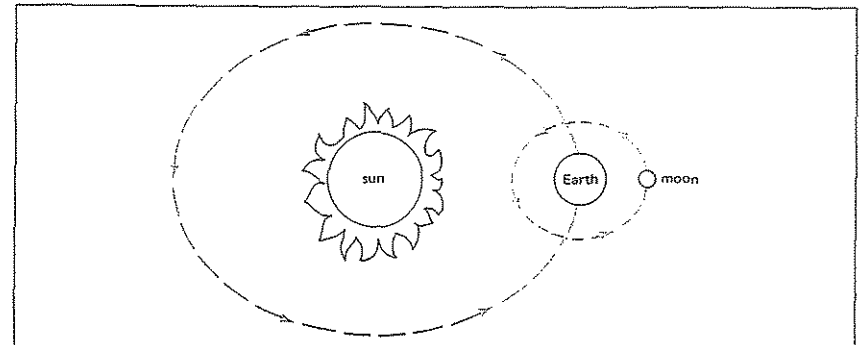


Figure C

The earth moves around the sun. The earth is a satellite of the sun.

The moon moves around the earth. The moon is a satellite of the earth.

SPACE SCIENCE

The study of outer space is more than the study of astronomy. It is also the study of space science.

Space science led to the Space Age. The Space Age began in 1957. In that year, Russian scientists placed the first artificial satellite (Sputnik) into orbit. Many other satellites have been placed into orbit since then. Unmanned spacecraft have landed on Mercury, Venus, and Mars. American astronauts have walked on the moon.

The space program helps us in many ways—here on earth—every day. These are some examples.

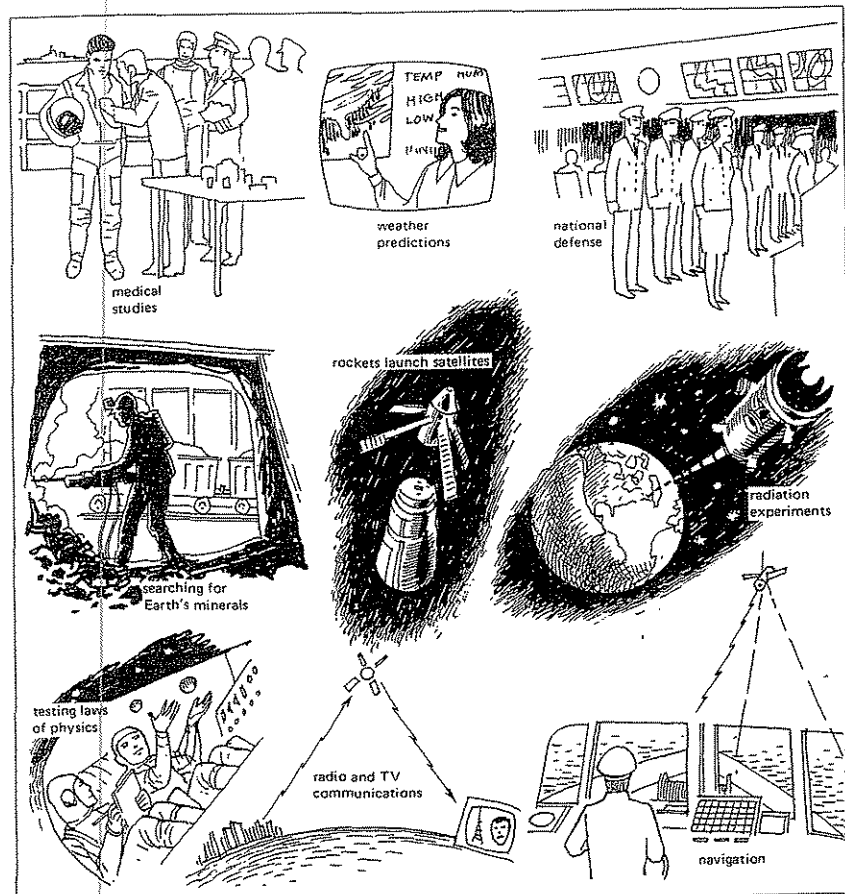


Figure D

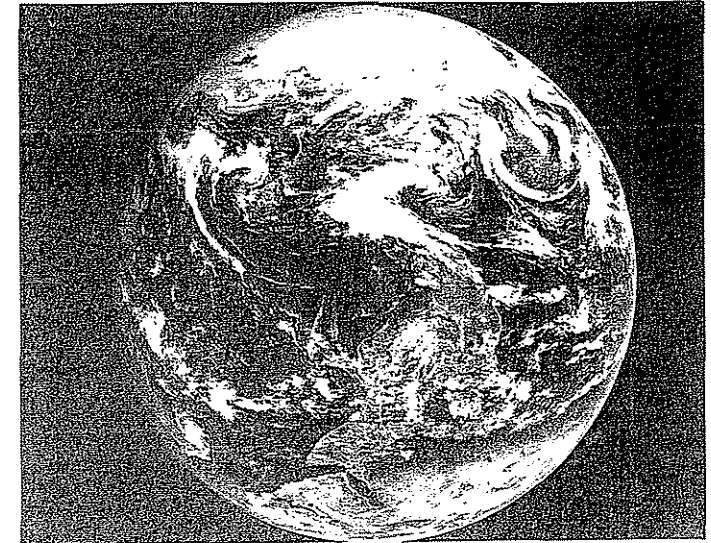


Figure E

A photograph taken from a spacecraft shows us what the earth really looks like.

Fill in the correct answer for each of the following.
THE BLANK

1. What do we call the study of heavenly bodies? _____
2. What do we call a scientist who studies heavenly bodies? _____
3. Which heavenly body did early people think was the center of the universe?

4. Which scientist first showed that the earth is not the center of the universe?

5. a) When did the Space Age start? _____
b) What event started it? _____
6. The earth has one natural satellite. What is its name? _____
7. List two ways in which satellites help us here on earth.

TRUE OR FALSE Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

1. _____ People have always understood outer space.
2. _____ Today, we know everything there is to know about space.
3. _____ Early people believed that the earth was the center of the universe.
4. _____ We know for certain that the universe has no end.
5. _____ The sun, the moon, and the stars are in space.
6. _____ The earth is in space.
7. _____ The earth is a satellite.
8. _____ The earth is a satellite of the moon.
9. _____ The earth is an artificial satellite.
10. _____ Satellites can help relay TV shows.

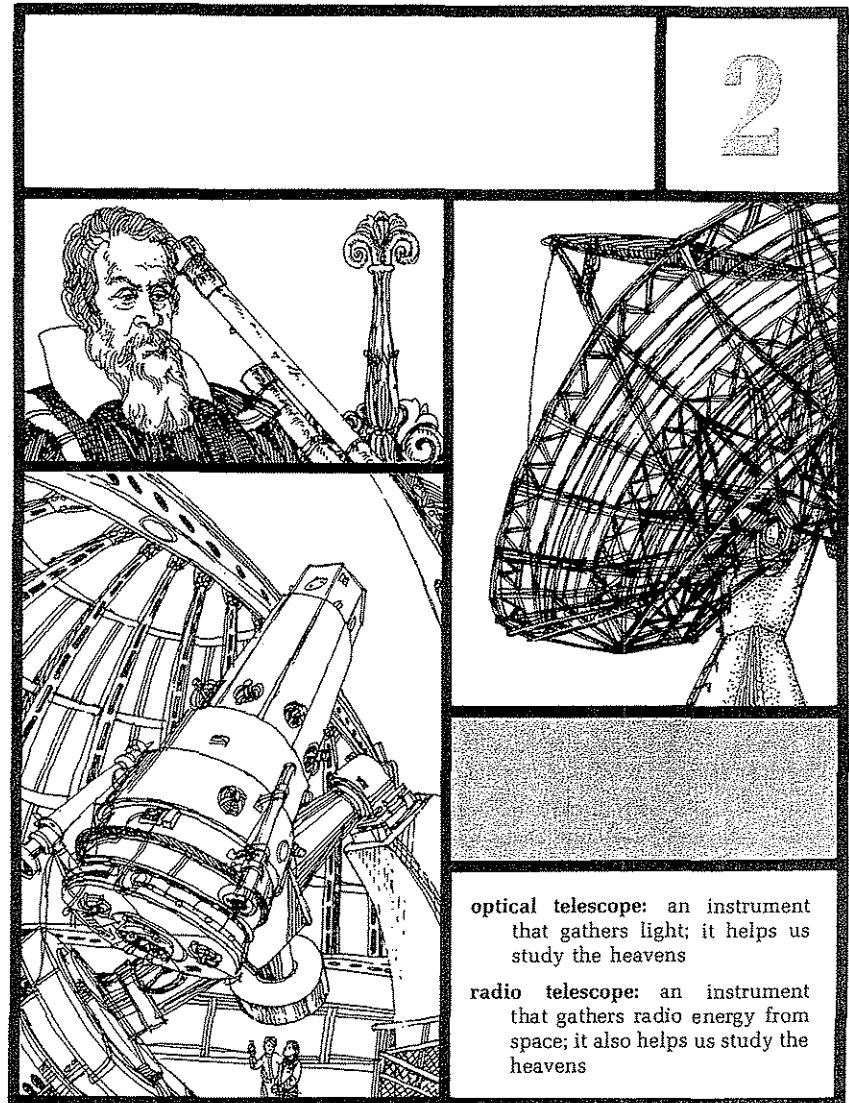
SPELL THE MISSING WORD Fill in the missing letters to spell the terms that fit the definitions.
When you have answered correctly, you will spell another term in the box.

- | | | | | | | |
|----|---|---|---|---|---|---|
| 1. | | | p | | c | |
| 2. | a | | e | | l | t |
| 3. | | l | | n | | t |
| 4. | a | t | | o | o | y |

1. _____ Age
2. an object that moves around another
3. the earth is one
4. the study of heavenly bodies

WHAT IS A TELESCOPE?

2



optical telescope: an instrument that gathers light; it helps us study the heavens

radio telescope: an instrument that gathers radio energy from space; it also helps us study the heavens

AIM | What is a telescope?

2

American astronauts have walked on the moon. But long before they did, telescopes gave us a good idea of what the moon's surface looks like.

You can see the planet Saturn with your eyes alone. But you cannot see its rings. A telescope shows the rings clearly.

Jupiter is visible to the naked eye, too. But you cannot see its moons. Using even a low-power telescope, you can see four of its moons. But with a high-power telescope you can find that there are at least eight more.

There is no question about it. . . . The most useful tool in astronomy is the telescope.

What is a telescope? Let's find out!

There are two main types of telescope: the optical telescope and the radio telescope.

OPTICAL TELESCOPE An optical telescope is an instrument that gathers and magnifies light from faraway places. It makes distant objects seem much larger and closer than they really are.

There are two kinds of optical telescope: the refracting telescope and the reflecting telescope.

A refracting telescope uses lenses to gather light. A reflecting telescope uses mirrors.

RADIO TELESCOPE A radio telescope does not gather light. A radio telescope gathers invisible radio energy from objects deep in space. The signals give us clues about the location and makeup of the objects.

MORE ABOUT TELESCOPES



Figure A

The optical telescope was invented in 1608 by a Dutch lens maker named Hans Lippershey. But, strange as it seems, he was refused a patent.



Figure B

An Italian astronomer named Galileo made the first practical use of Lippershey's invention.

In 1609, Galileo made his first telescope. It was crude and low powered. Yet, it enabled him to make important discoveries. Galileo was the first person to see mountains and craters on the moon, the rings of Saturn, and four of Jupiter's moons.



Figure C

Many of today's toy telescopes are more powerful than the telescopes Galileo used!

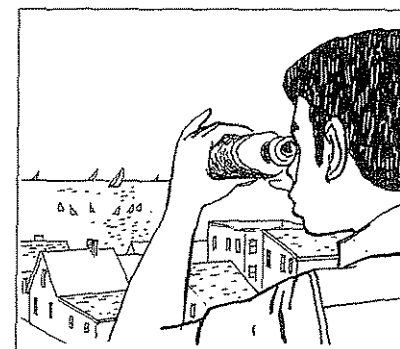


Figure D

What are binoculars? Simply two low-power land telescopes connected together.

UNDERSTANDING ASTRONOMICAL TELESCOPES

Figures E and F show two types of telescope. Follow the rays of light as you read about each one. Then answer the questions by letter.

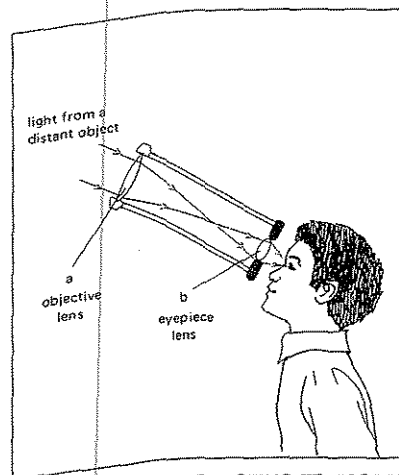


Figure E THE REFRACTING TELESCOPE

- The objective lens gathers light from a distant object.
- It forms a small but bright image.
- The eyepiece lens magnifies the image greatly.

1. Which part gathers light? _____
2. Which part magnifies? _____

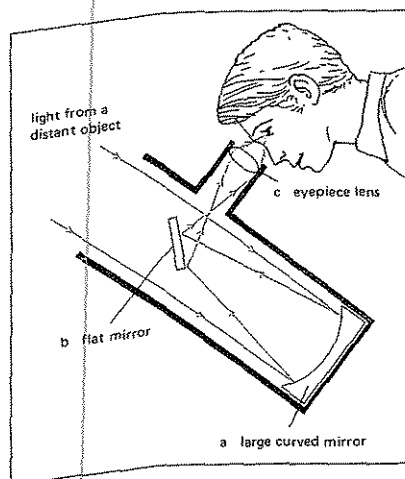


Figure F THE REFLECTING TELESCOPE

- A large curved mirror gathers light from a distant object.
- The light reflects onto a flat mirror. A small but bright image is formed.
- The eyepiece lens magnifies the image greatly.

3. Which part gathers light? _____
4. Which part magnifies? _____
5. Which part is a lens? _____

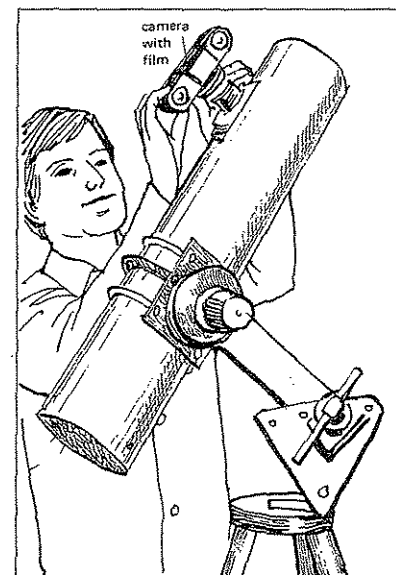


Figure G

Many optical telescopes have a camera attached to the eyepiece. The camera takes a picture of the image. The picture is then studied.

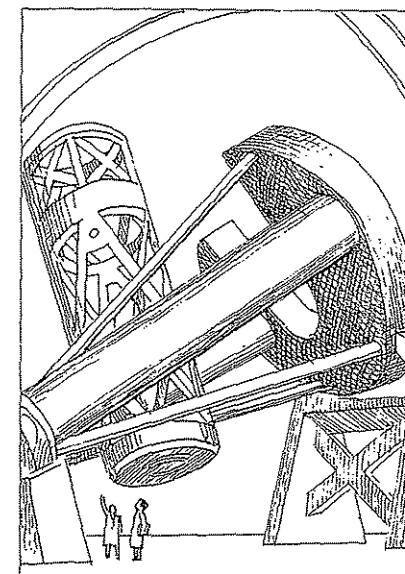


Figure H

This giant reflecting telescope is at Mount Palomar, California. Its mirror is 508 cm (200 inches) across. The larger the lens or mirror, the more light it gathers.

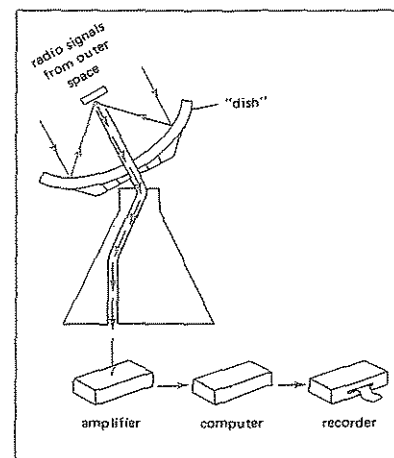
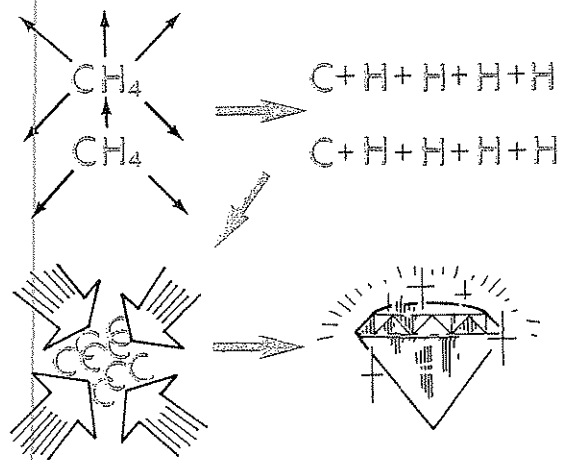


Figure I THE RADIO TELESCOPE

Look at Figure I. Follow the radio waves.

1. A huge "dish" collects radio waves (signals) from a distant object.
2. The signal is reflected into an amplifier.
3. The amplifier makes the signal stronger.
4. The amplified signal is fed into a computer.
5. The signal is recorded on tape.

KEEPING UP WITH SCIENCE



DIAMONDS IN THE SKY

The lead in a pencil is not lead at all. It is graphite—a form of carbon. Diamond is also carbon. But the similarity ends there. The carbon in a pencil has very little value—a small fraction of a cent. But the same amount of carbon in a diamond is worth thousands of dollars.

How would you like to pick up diamonds—as many as you wish? You could—if you were on the planet Uranus or Neptune—at least, according to planetary scientist Marvin Ross.

Diamonds are formed in nature when carbon is squeezed (compressed). Very high heat and great pressure are needed.

Dr. Ross believes that Uranus and Neptune contain a layer of liquid methane (CH_4) and ammonia (NH_3). The temperature and pressure in this layer are thought to be very great:

- temperature—at least 3000°C (5400°F)
- pressure—about 200,000 times greater than Earth's atmospheric pressure.

But what does this have to do with making diamonds? The temperature is high enough to break the CH_4 molecule and so free the carbon.

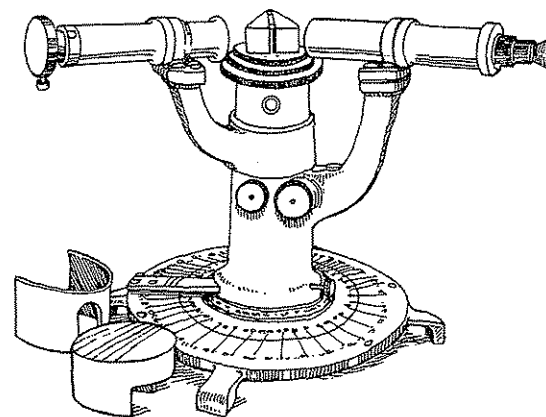
The pressure is great enough to compress the freed carbon into crystalline form, which are diamonds.

Uranus and Neptune are large planets. Each is nearly four times larger than Earth. And each is made up of about 20 percent carbon.

If Dr. Ross is correct in his theory, can you imagine the enormous quantity of diamonds these planets might contain? Want to take the trip?

WHAT IS A SPECTROSCOPE?

3



THUMB



spectroscope: an instrument used to study the light coming from an object

spectrum: a band of colors

AIM | What is a spectroscope?

Our sun is a star. Everyone knows this now. But the early scientists did not believe this. There was no proof! The key to the proof came in 1850 with the invention of the spectroscope [SPECK truh scope].

A spectroscope identifies elements by the colors they give off.

Every substance gives off light when it becomes hot enough. Every element gives off its own special color. A spectroscope separates the light into colored lines. We call these lines a spectrum. A spectrum is like a fingerprint. No two people have the same fingerprints. And, no two elements have the same spectrum. But the spectrum is always the same for a particular element.

For example:

1. This is what a sodium spectrum looks like.



Only sodium looks like this. No other element looks exactly like this.

2. This is what a boron spectrum looks like.



Only boron looks like this. No other element looks exactly like this.

There are about 90 natural elements. We know the spectrum for each one. About 67 of them have been found in sunlight. This means that the sun contains at least 67 elements that are found on earth.

How do we know that the sun is a star? Simple! The spectroscopy patterns of the sun and the stars are very similar.

UNDERSTANDING THE SPECTROSCOPE

The most important part of a spectroscope is a prism. A prism is glass shaped like a wedge.

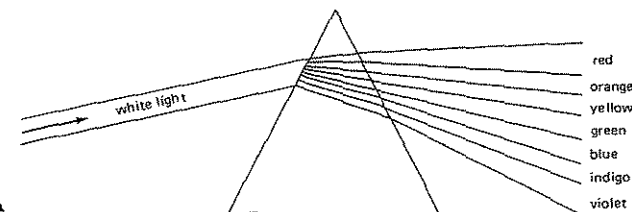


Figure A

A prism can break up white light into a rainbow of colors. This is the spectrum of white light.

In a spectroscope, a prism forms spectrums of individual elements.

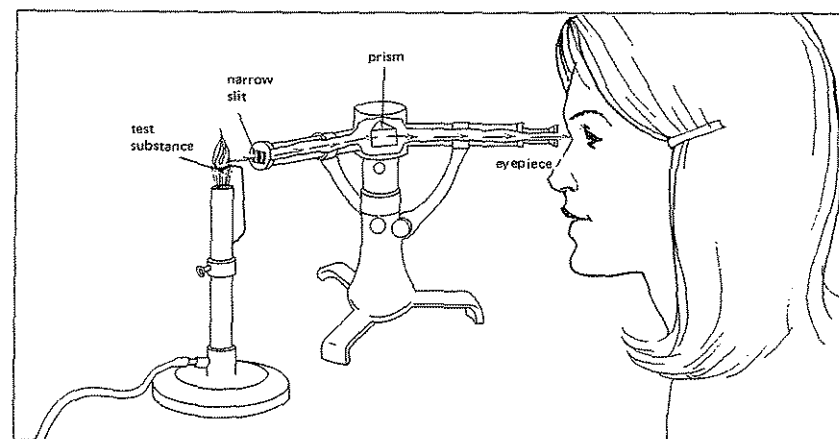


Figure B

HOW A SPECTROSCOPE WORKS

1. The substance to be tested is placed in a flame. The flame is in line with the narrow slit of the spectroscope.
2. Light from the heated substance enters the slit. It passes through the prism and into the eye of the viewer.
 - The prism "breaks up" the light. A particular spectrum is formed.
 - The observer identifies the spectrum.

IDENTIFYING SPECTRUMS

Figure C shows the spectrums of 9 elements. (The numbers stand for different colors.)

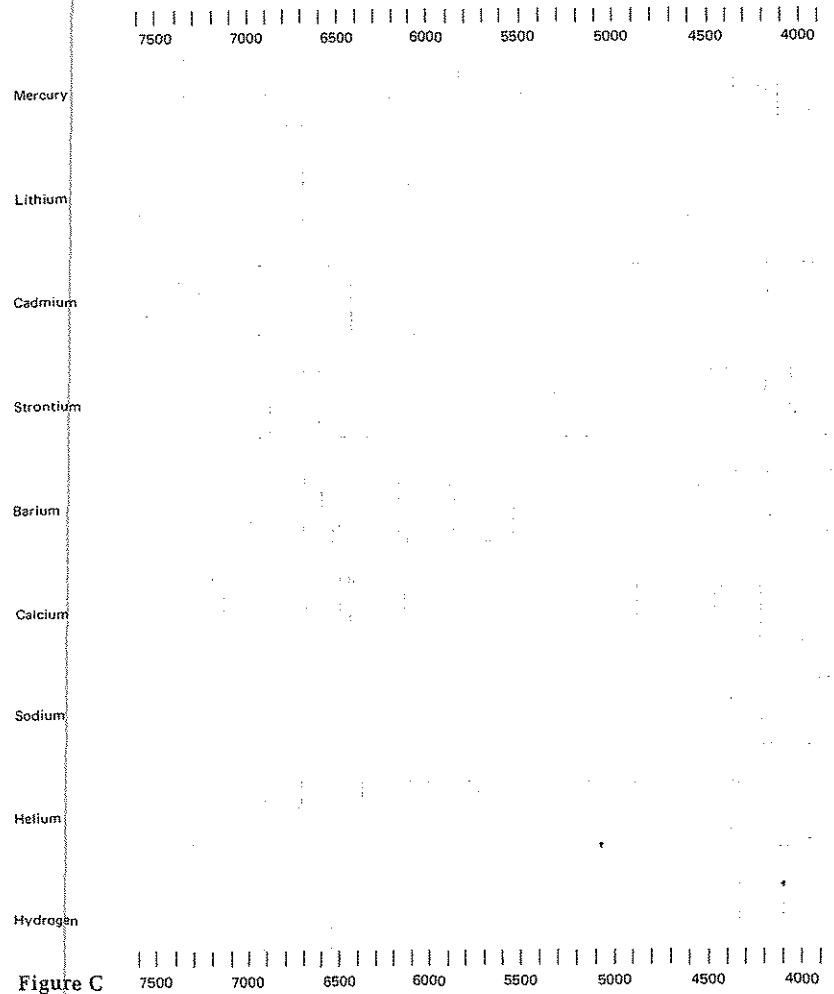
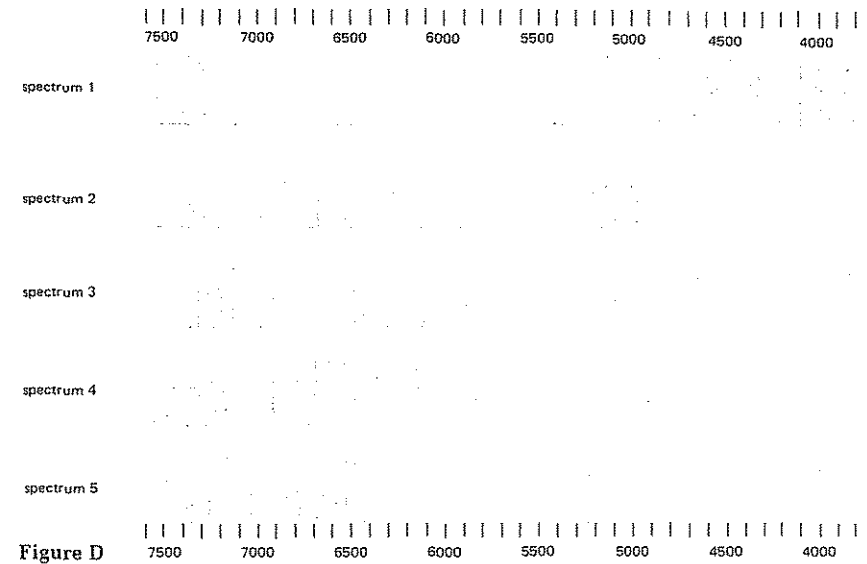


Figure D shows 5 spectrums coming from a heavenly body.

Use Figure C to find out which element is shown by each spectrum. Write your answers in the chart.



Spectrum	Element
1	
2	
3	
4	
5	

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|----------------------------|-------------------------------|
| 1. _____ astronomy | a) key part of a spectroscope |
| 2. _____ optical telescope | b) band of colors |
| 3. _____ spectroscope | c) analyzes light |
| 4. _____ prism | d) gathers light |
| 5. _____ spectrum | e) study of the heavens |

HOW A SPECTROSCOPE IS USED

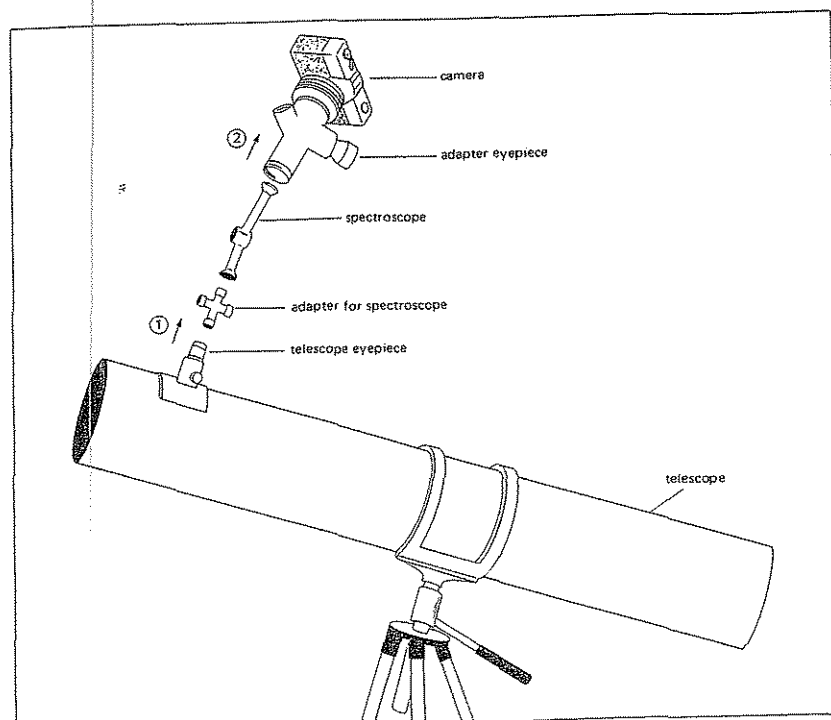


Figure E

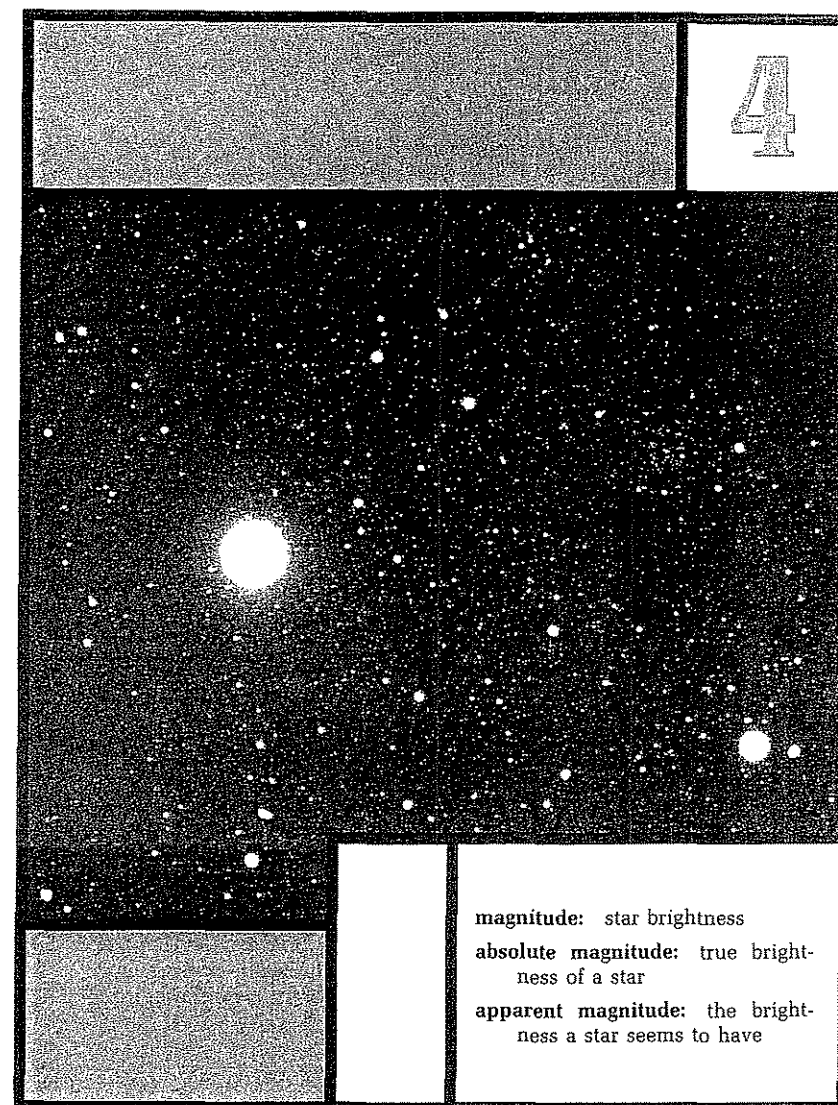
How is a spectroscope used to study light from objects in space? Figure E shows how.

- The spectroscope is connected to the telescope (1).
- A camera is connected to the spectroscope (2). The camera photographs the spectrum.
- Astronomers study and identify the spectrum.

The spectroscope does more than identify the chemical makeup of the sun and the stars. The spectroscope tells us:

1. The makeup of the atmosphere of planets
2. How fast a heavenly body moves and in which direction
3. How hot a star is
4. If a star is rotating
5. If a star has a magnetic field

WHAT ARE STARS LIKE?



magnitude: star brightness
absolute magnitude: true brightness of a star
apparent magnitude: the brightness a star seems to have

AIM | What are stars like?

4

If something is hot enough, it will "glow." It will give off light. Stars are made up of very hot gases. "Starlight"—the light given off by stars—is the light given off by the very hot gases that make up the stars.

Without a telescope, stars look like tiny points of white light. Actually, light from different stars can be different in two important ways—color and brightness.

COLOR

When viewed through a telescope, stars have different colors. The color of a star depends on its temperature. The hottest stars are bluish white. The coolest stars are reddish-orange. "Medium-hot" stars are yellow.

BRIGHTNESS

There are two "kinds" of brightness—true brightness and apparent brightness. True brightness depends on size and temperature. The bigger and hotter an object is, the brighter it will actually be.

Apparent brightness depends mostly on distance. For example, a dim light that is close will seem brighter than a bright light that is farther away. Thus, a dim star that is close to Earth will appear brighter than a bright star that is farther away.

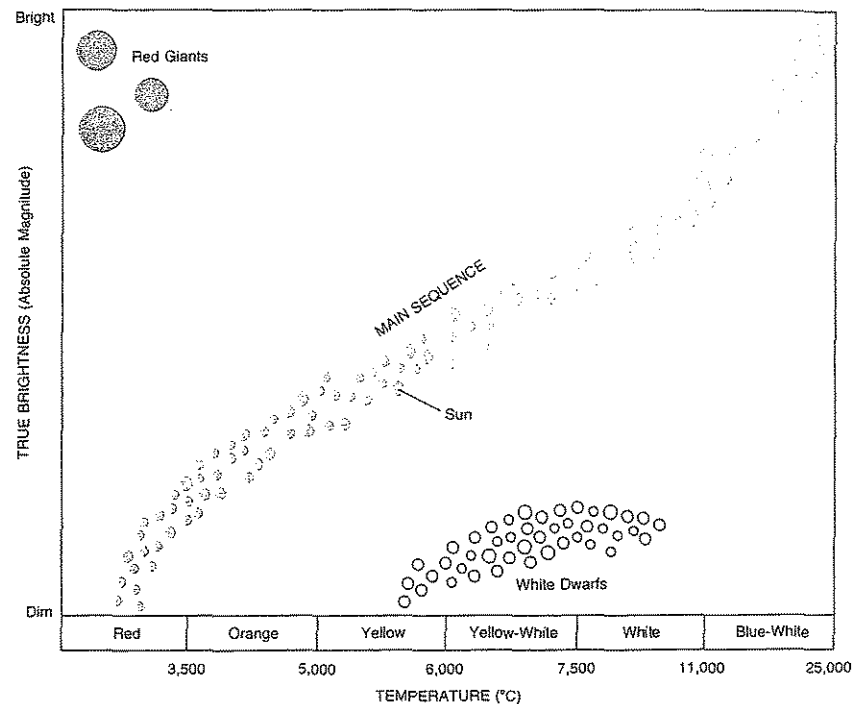
Star brightness is called magnitude (MAG nuh tood). The true brightness of a star is called absolute magnitude. But, this is not the brightness we see when we look up at the stars. The stars that appear brightest are those closest to Earth. This brightness is called apparent magnitude.

THE BRIGHTEST STAR

Our sun is a medium-size, medium-hot star! There are tens of millions of stars brighter than the sun. Why, then, does the sun appear to be so much larger and brighter than all the other stars? Because it is so much closer to Earth than the next nearest star. The sun's brightness is apparent brightness!

STAR STUDIES

In the chart below, stars are grouped by color (temperature) and true brightness (absolute magnitude). Cool (red) stars are on the left. Hot (blue-white) stars are on the right. Most stars are found in an area called the main sequence.



- On this chart, the brightest stars are near the _____
top, bottom
- This chart shows that the color of the hottest stars is _____.
- The temperature of the sun is about _____ degrees C and its color is _____.
- The two groups of stars that are not on the main sequence are _____ and _____.
- The temperature range of yellow-white stars is between _____ °C and _____ °C.

STUDYING BRIGHTNESS

Study Figures C and D. Answer the questions.

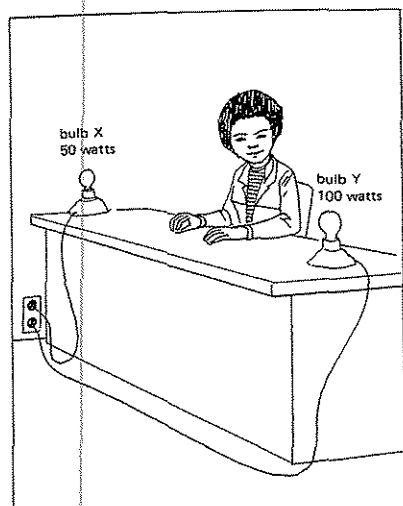


Figure C

Figure C shows two light bulbs. Both are the same distance from the girl.

1. Which bulb glows more brightly?

_____ X, Y

2. You would make both bulbs seem brighter by moving them _____ the girl.

_____ closer to, farther away from

3. How would you make bulb X seem as bright as bulb Y? List two ways.

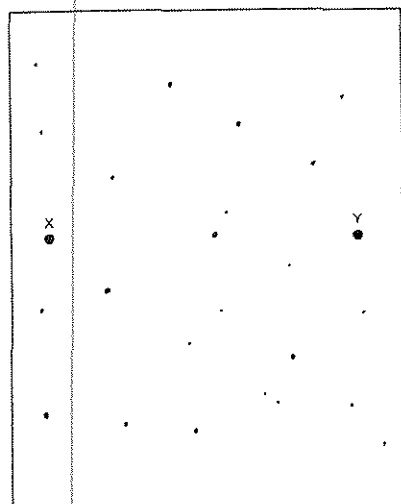


Figure D

Figure D shows stars. Stars X and Y seem equally bright. Yet, X really gives off more light than Y.

4. Which star is farther away?

_____ X, Y

5. Which star is closer? _____ X, Y

6. _____ stars are those that are over 326 light-years away.

_____ Nearby, Distant

7. To find how far it is to a distant star we compare _____ size, brightness

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|------------------------------|-----------------------------------|
| 1. _____ star color | a) a yellow star |
| 2. _____ true brightness | b) stars not on the main sequence |
| 3. _____ Red Giants | c) depends on temperature |
| 4. _____ apparent brightness | d) absolute magnitude |
| 5. _____ the sun | e) depends on distance |

COMPLETING SENTENCES Complete the sentences with the choices below.

blue-white
temperature
true
Red Giants

apparent magnitude
absolute magnitude
the sun
starlight

yellow
distance
hot gases
orange

- Stars are made up of very _____.
- Apparent brightness depends mostly on _____.
- The color of the hottest stars is _____.
- Large, cool stars that are not on the main sequence are _____.
- "Medium-hot" stars are _____.
- Star color depends mostly on _____.
- _____ is the light given off by stars.
- The brightest star in our sky is _____.
- _____ brightness depends on size and temperature.
- The true brightness of a star is called _____.

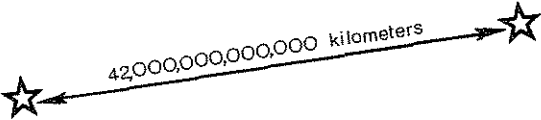
WORD SEARCH

The words in the list are hidden in the groups of letters. Try to find each word. Draw a line around the word. The spelling may go in any direction: up-and-down, across, or diagonally.

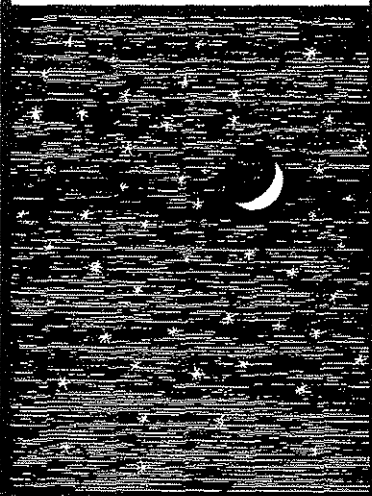
STARLIGHT
APPARENT
BRIGHTNESS
TEMPERATURE
RED GIANT
SUN
MAGNITUDE
DISTANCE
COLOR
ABSOLUTE

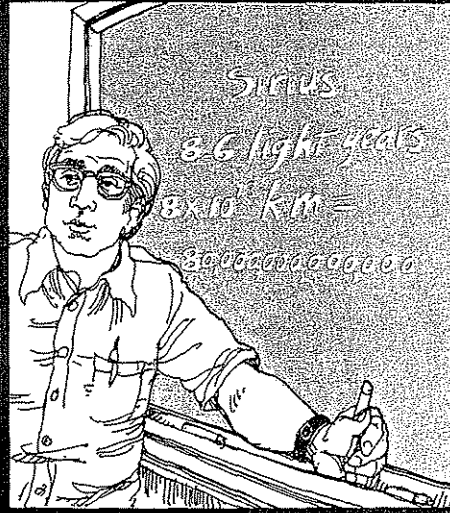
P	R	E	A	L	F	C	O	N	T	E	R
S	A	T	T	N	A	I	G	D	E	R	N
M	O	U	S	E	D	O	O	R	M	A	T
A	L	L	W	E	R	T	Y	O	P	S	H
G	R	O	A	N	I	W	A	S	E	L	G
N	A	S	A	L	C	O	L	O	R	X	I
I	M	B	S	O	L	U	R	E	A	E	L
T	U	A	P	P	A	R	E	N	T	O	R
U	N	D	E	R	O	V	E	R	U	P	A
D	I	S	T	A	N	C	E	A	R	S	T
E	X	B	R	I	G	H	T	N	E	S	S

HOW FAR AWAY ARE THE STARS?



5





light-year: the distance that light travels in one year

AIM | How far away are the stars?

5

The sun is a star. No question about that! But, usually, we do not think of the sun as a star. When we say "star," we usually mean those stars that are beyond our sun.

Our sun is far away—about 150 million kilometers (93 million miles).

Think of it! You would need 31,000 Americas laid end to end to equal this distance. Yet, compared to the distance to the closest star, this is almost no distance at all.

The stars are so far away that we don't measure their distances in kilometers or miles. The number would be too long and it would have little meaning.

Star distance is measured in a special unit called the *light-year*.

What is a light-year?

A LIGHT-YEAR IS THE DISTANCE THAT LIGHT TRAVELS IN ONE YEAR.

Let's see what this means.

- Light travels about 300,000 kilometers (186,000 miles) every second.

- There are 31,536,000 seconds in a year.

- If you multiply the seconds in a year by the speed of light, you find out how far light travels in one year.

How far is it? Nearly 10 trillion (10,000,000,000,000) kilometers (6 trillion miles). This is one *light-year*.

10 trillion kilometers! Wow! That's equal to 2 *billion* (2,000,000,000) Americas laid end to end.

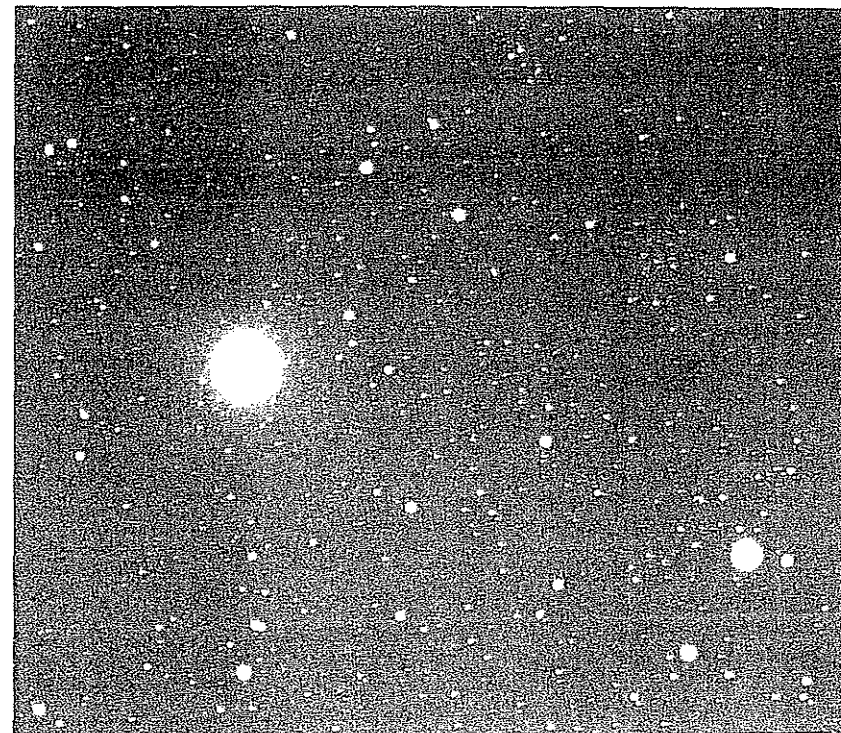


Figure A

The closest star (other than our sun), is 4.3 light-years away.

That's 42,000,000,000,000 kilometers

or

26,000,000,000,000 miles.

Now here's something to think about.

Most other stars are millions and hundreds of millions of light-years away!

In fact, some stars in distant galaxies (star systems) are believed to be about 16 billion light-years away.

This distance looks like this in kilometers:

16,000,000,000,000,000,000 kilometers

Here is the same distance in miles:

9,600,000,000,000,000,000 miles.

Now do you see why star distances are measured in *light-years* and not in kilometers or miles?

COMPLETING SENTENCES Complete the sentences with the choices below.

150 million kilometers
star
one year
kilometers

ten trillion
300,000
light-year

light
second
stars

1. The sun is a _____.
2. The sun is _____ from earth.
3. All the other _____ are much farther than the sun.
4. We do not measure star distance in _____.
5. Star distance is measured in a unit called the _____.
6. A light-year is the distance that _____ travels in _____.
7. Light travels _____ kilometers per _____.
8. One light-year is equal to about _____ kilometers.

FIGURING DISTANCES FROM LIGHT-YEARS

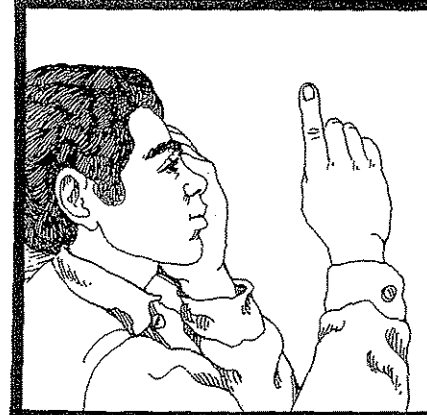
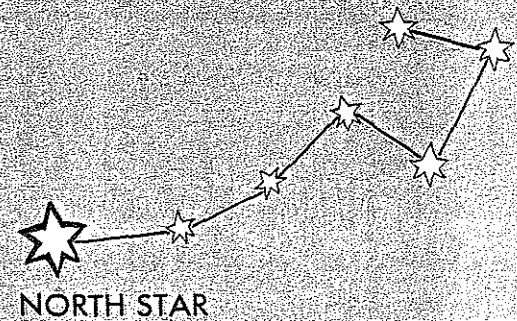
Six different light-year distances are listed below. What distance (in kilometers) does each one stand for?

Write the distance in numbers in the second column. Then write the distance in words in the third column.

Number of Light Years	Distance (in numbers)	Distance (in words)
7	km	
5	km	
9	km	
6	km	
18	km	
100	km	

HOW DO WE MEASURE STAR DISTANCE?

6



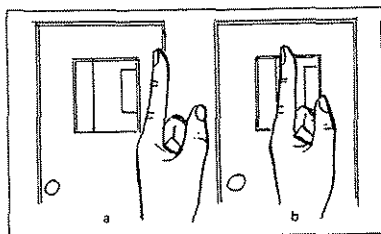
parallax: shift of position an object seems to have when it is seen from two different points
constellation: a group of stars that form a pattern

AIM | How do we measure star 6 distance?

We can find out how far away distant stars are by comparing their brightness. But we measure the distance to nearby stars in a different way. This method depends upon a trick that our eyes play on us.

Any object seems to shift position when it is viewed from two different points. We call this apparent shift in position *parallax*.

You can see parallax while sitting at your desk. Do this:



1. Hold one finger a short distance in front of your face.
2. Close your right eye.
3. Now open your right eye and close the left.
4. Repeat this several times.

Your finger didn't move. But it seemed to. It seemed to move back and forth compared to the background. It is this apparent shift that we call *parallax*.

Parallax lets us measure the distances to many stars. It even helps us measure the size of the sun, moon, and planets.

The facing page shows you how parallax helps us measure star distances.

HOW DO WE MEASURE STAR DISTANCES?



Figure B

All stars are very far away. But some stars are much farther away than others. In fact, many stars are so far away, that they make closer stars seem "nearby."

To measure star distances, we separate stars into two groups: distant (or "far-off") stars and nearby stars.

- Nearby stars are up to 326 light-years away.
- Distant stars are farther than 326 light-years away.

Distances of stars in each group are measured in a different way. Let's see how distant stars are measured.

We find how far it is to distant stars by comparing star brightness.

Some stars give off more light than others. The brightness we see depends upon two things:

1. how much light a star gives off, and,
2. how far away the star is.

A star is like any other light source.

- The closer a light is, the brighter it seems.
- The farther a light is, the dimmer it seems.

To find how far away a distant star is, we compare the brightness of the distant star to the brightness of a nearby star whose distance we already know.

USING PARALLAX

STEP 1

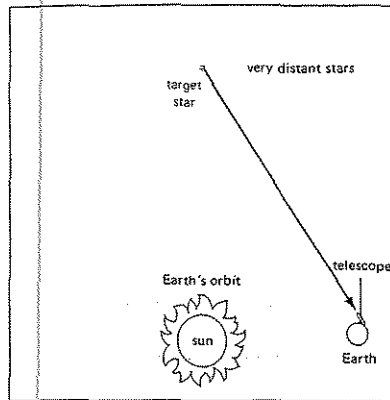


Figure A

A nearby "target" star is chosen. Distant stars are in the background. They are photographed together.

STEP 2

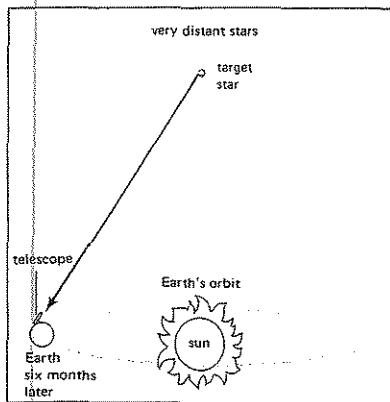
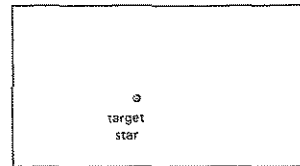


Figure D

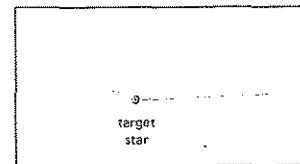
A second photograph is made six months later. The earth is then exactly at the opposite end of its path around the sun.

Figure B



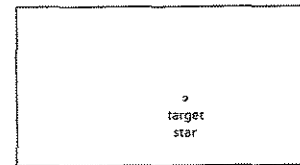
This is what the photograph might look like. The distant stars are reference stars.

Figure C



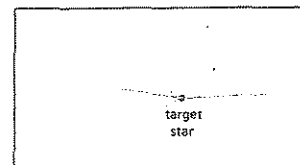
The distances between the target star and each reference star are measured.

Figure E



This is what the photograph might look like.

Figure F



The distances between the target star and the same reference stars are measured.

Compare the two photos.

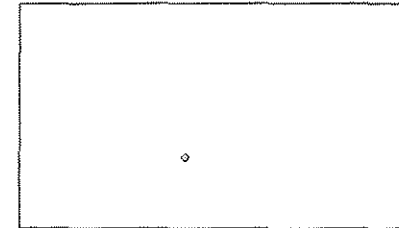


Figure G

This is the first photo.

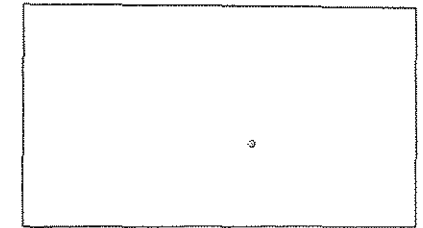


Figure H

This is the one taken six months later.

Notice that the target star is not in the same spot. It seems to have shifted compared to the reference stars.

Astronomers measure how far the target star seems to have shifted.

The distance is changed to an angle measurement. This is called the *angle of greatest shift*.

STEP 3

The final step is simple math. A triangle is set up as in Figure I.

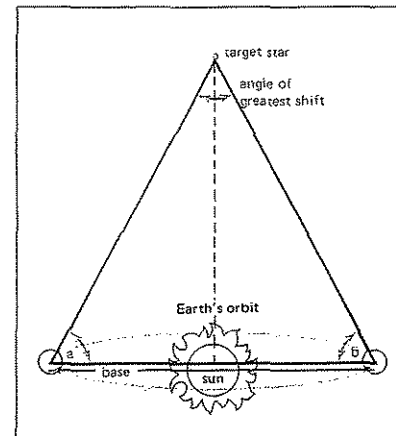


Figure I

The base is the distance between the earth's position six months apart. This distance is known.

The angle of greatest shift lets us find angles a and b.

With these figures, we can find the distance to the target star.

COMPLETING SENTENCES Complete the sentences with the choices below.

distances
two
nearby
kilometers

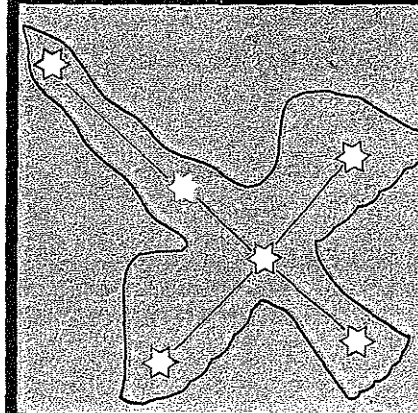
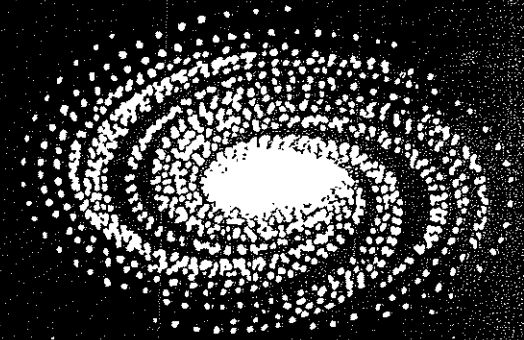
halfway
size
parallax
six months

shift position
light-years
target star

1. Every object seems to _____ when seen from two different places.
2. This apparent shift in position is called _____.
3. Parallax allows us to measure the _____ between objects in spaces.
4. Parallax can be used to measure the distances of only _____ stars.
5. Parallax can be used to measure more than star distance. Parallax can also be used to measure the distances and _____ of the sun, moon, and planets.
6. To measure star distance, at least _____ observations are needed.
7. The second observation is made exactly _____ after the first.
8. In six months the earth has traveled _____ through its path around the sun.
9. Astronomers know how far the earth travels in six months. They observe the angle of greatest shift. From this they can figure the distance to the _____.
10. The distances to stars is measured in _____, not in _____.

WHAT ARE GALAXIES AND CONSTELLATIONS?

7



galaxy: star system

Milky Way galaxy: the galaxy in which the sun is located

constellation: a group of stars that form a pattern

AIM | What are galaxies and 7 | constellations?

Look up at the sky on a clear night. How many stars can you see? Take a guess. One hundred? One thousand? One million? Without a telescope, about 5,000 stars are visible from Earth. That is, from the entire Earth! Not from your back yard.

Through a powerful telescope, millions of individual stars can be seen. Does this mean that most of the stars are visible through a telescope? Not quite. Astronomers believe that there are about 200 billion billion (200,000,000,000,000,000,000) stars out there in space!

Stars are not just scattered throughout space. They are sort of bunched together in very large groups or systems, called *galaxies* (GAL uk sees). Each galaxy contains hundreds of millions of stars. And the galaxies are millions of light-years apart.

There are three main types of galaxies—spiral (SPY rul), elliptical (ee LIP tik ul), and irregular.

A *spiral galaxy* looks something like a giant pinwheel. It has a thick center and several "arms" that spiral around the center. The planet Earth is located in a spiral galaxy—the Milky Way galaxy. Our sun is one of more than 100 billion stars in this galaxy.

An *elliptical galaxy* looks something like the lens of a magnifying glass. It has no arms, and most of the stars are concentrated near its center.

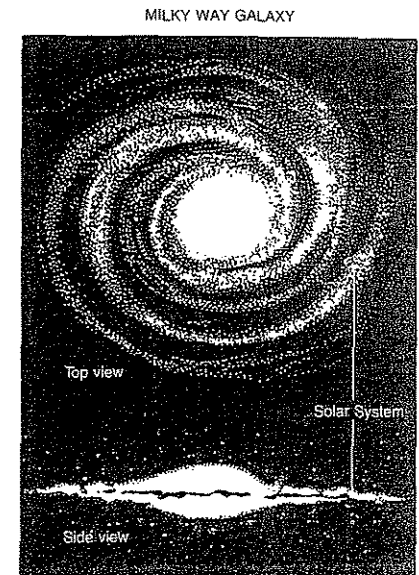
Irregular galaxies have no definite shape.

You may have noticed that certain groups of stars seem to form shapes, or patterns. In fact, you may be able to pick out some of these patterns, such as the "Big Dipper" and the "Little Dipper."

Since ancient times, people have noticed star patterns. Many of these patterns—88 of them—have been given names. Groups of stars that form a pattern are called *constellations* (kon stuh LAY shuns).

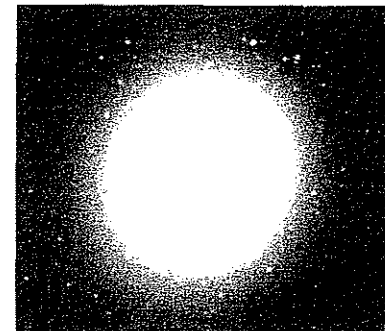
A LOOK AT THE MILKY WAY

Look at the drawing on page 35. It shows a *spiral galaxy*. The galaxy is thousands of light years from Earth. The Milky Way galaxy is a spiral galaxy much "closer to home." Look at the picture of the Milky Way. It shows "top" and "side" views of the galaxy. Notice where the sun is located in the Milky Way. Our planet, Earth, is very close to the sun. Earth is part of the Milky Way.

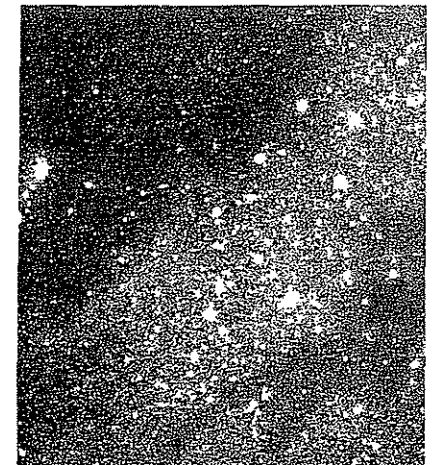


OTHER TYPES OF GALAXIES

An *elliptical galaxy*. These galaxies are thicker in the middle than they are at the edges.



An *irregular galaxy*. These galaxies have no definite shape



WHAT ARE SOME FAMILIAR STARS?

You have probably gazed up at the stars. Have you ever noticed the patterns that they seem to make? People have noticed these patterns since ancient times.

Groups of stars that form patterns are called constellations [kon stuh LAY shuns]. Actually, the stars of a constellation may not be close to one another at all. They just look that way to us here on earth.

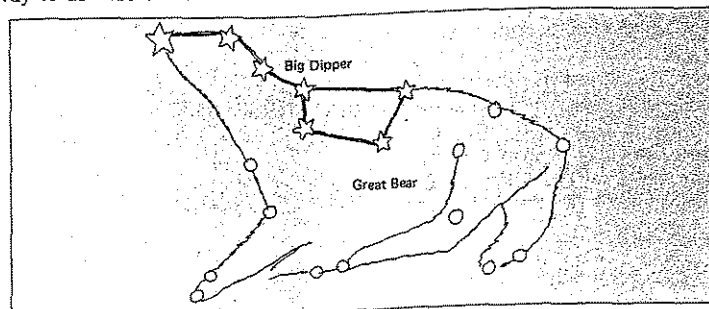


Figure A

The Big Dipper is part of an even bigger constellation, the Great Bear.

1. How many stars make up the Big Dipper? _____

The North Star is found at the end of the Little Dipper's handle.

The North Star is important for ships and planes to guide themselves.

2. Circle the North Star on Figure B.

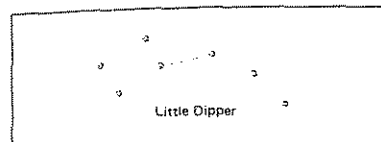


Figure B

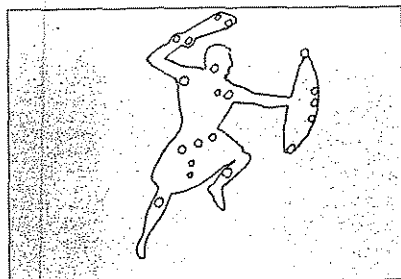


Figure C

Ancient people saw a hunter in the constellation Orion [oh RYE un]. Orion has a "belt."

3. Draw a line through his belt.

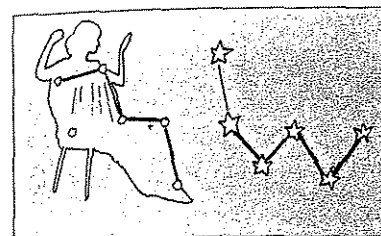


Figure D

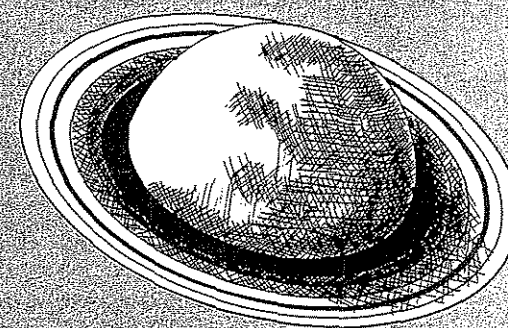
According to myth, Cassiopeia [kas ee uh PEE uh] was an Ethiopian queen. She appears on her side in the sky.

4. What letter of the alphabet does this constellation form? _____

V. W

WHAT IS THE SOLAR SYSTEM?

8



Solar System: the sun and all the objects that orbit it

planets: nine large bodies that orbit the sun

moon: a body that orbits a planet

asteroids: large rocks that orbit the sun in a belt between Mars and Jupiter

meteoroids: small bits of rock that are part of the Solar System

AIM | What is the solar system? 8

Everywhere you look today, you see the word "solar." Solar energy. Solar power. What, exactly, does the word solar mean? It means "of or relating to the sun."

The solar system, then, is "the system of the sun." This system is made up of the sun and all of the objects that travel around the sun. These objects travel in "paths," called orbits. They are held in their orbits by the sun's gravity.

Except for the sun itself, the most important objects in the solar system are the *planets*. Nine planets, including Earth, orbit the sun.

Other objects also travel around the sun and are part of the solar system. These objects are listed here.

Moons Most planets have moons. Moons orbit the planets.

Asteroids Asteroids (ASS tuh royds) are large chunks of rock. Most of the asteroids are found in a "belt" between the planets Mars and Jupiter.

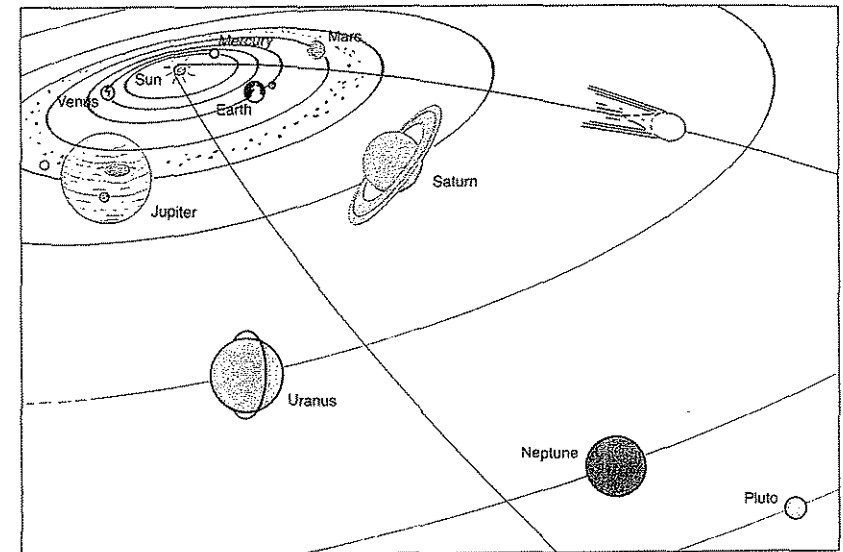
Comets Comets are thought to be made up of rocks, dust, and ice. Comets travel around the sun in long, "cigar-shaped" orbits. The most famous comet in the solar system is Halley's Comet. It takes Halley's Comet 76 years to complete one trip around the sun.

Meteoroids Meteoroids (MEE tee uh royds) are small bits of rock. Some are as small as a grain of sand. When a meteor enters the earth's atmosphere, it burns up. While it is burning, it is called a *meteor*, or "shooting star." A meteor that reaches the earth's surface is called a *meteorite*.

Starting with the planet closest to the sun, the names of the planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. The four planets closest to the sun are known as the *inner planets*. The next four are known as the *outer planets*. At this time, not much is known about Pluto.

THE SOLAR SYSTEM

A. Study the drawing. Then fill in the chart, listing the planets in order. Start with the planet closest to the sun.



Order of Planets from the Sun		
1.	(closest)	
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.	(farthest)	

B. Fill in the chart. List the planets in order from largest to smallest. Use the drawing on page 41.

Planet Size	
1. (largest)	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9. (smallest)	

TRUE OR FALSE Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

1. _____ Mercury has several moons.
2. _____ Jupiter is the largest planet.
3. _____ Earth is one of the inner planets.
4. _____ Uranus is smaller than Pluto.
5. _____ A comet is also called a "shooting star."
6. _____ The asteroid belt is between Jupiter and Mars.
7. _____ Venus is closer to the sun than Mars.
8. _____ Saturn is surrounded with bright rings.
9. _____ The outer planets are smaller than the inner planets.
10. _____ The farthest planet from the sun is Pluto.

FACTS ABOUT THE SOLAR SYSTEM

1. The four planets closest to the sun are called the inner planets. Write the names of these four planets.
2. The next four planets are called the outer planets. Write the names of the outer planets.

3. Look at the drawing on page 41. Name the three planets that do not have at least one moon.

COMPLETING SENTENCES Complete the sentences with the choices below. Use the drawing on page 41 to help with the answers.

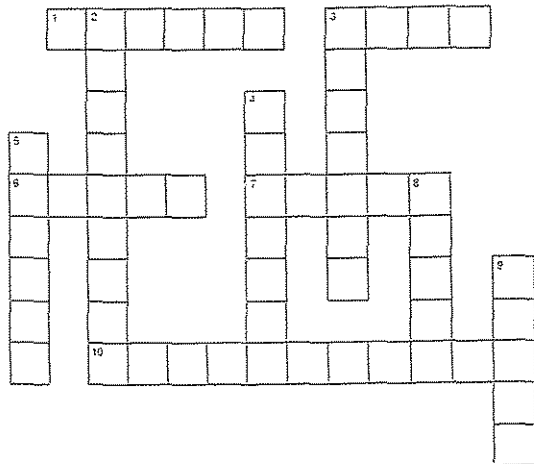
Solar System
Earth
asteroids
Jupiter

Saturn
Pluto
comet
Mercury

Neptune
Meteoroids

1. The planet closest to the sun is _____.
2. The _____ is the sun and all the objects that travel around it.
3. _____ is the only planet with one moon.
4. The farthest planet from the sun is _____.
5. The _____ are the belt of rocks between Mars and Jupiter.
6. _____ is the largest planet.
7. _____ are small bits of rock that orbit the sun.
8. A _____ travels in a long, "cigar-shaped" orbit.
9. _____ is between Uranus and Pluto.
10. The planet with the rings is _____.

CROSSWORD Fill in the blank spaces by following the clues across and down.
PUZZLE



Across

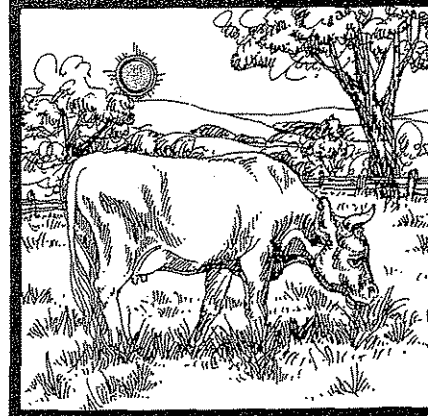
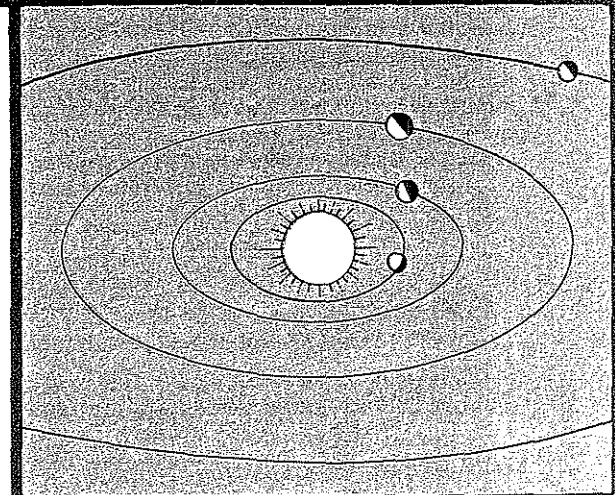
1. Planet with rings
3. Body that orbits a planet
6. The planet we live on
7. Farthest planet from the sun
10. The sun and everything that travels around it

Down

2. Found in a belt between Mars and Jupiter
3. Planet nearest to the sun
4. Largest planet
5. "Shooting star"
8. "Paths" in which objects travel around the sun
9. Travels in long, cigar-shaped orbit around the sun

WHY IS THE SUN IMPORTANT?

9



fuel: anything that is burned for its energy

AIM | Why is the sun 9 | important?

The sun is as important as life itself. For without the sun, there would be no life. In fact, there would be no earth!

What would happen if the sun were to suddenly disappear? What then? The earth would have nothing to hold it in place. It would shoot out into space. The moon would seem to disappear because it would be almost pitch black. Only faint light from the stars would reach the earth. But the light would make no difference, for all life would die out. The temperature would drop to hundreds of degrees below zero. Nothing could live in such cold. The earth would be a dead and frozen world. It would travel forever into endless space.

This probably will happen some day. But not for billions of years. So sleep peacefully tonight!

Let's get back to the earth of right now! Look around. There is life everywhere. There is warmth, wind, and rain. There is food to eat. We can thank the sun for all this.

Plants need the sun to grow. And without plants there would be no food. There would be no oxygen in the air.

The sun heats the earth. The heat causes winds. The heat also evaporates water from the earth's surface. The evaporated water forms clouds. The clouds return the water to the earth as rain and snow. Plants and animals need the water to live.

If it weren't for the sun, we would have no coal, oil, or gas. Oil and gas probably formed from microscopic plants and animals. They could not have lived without the sun.

Where did the sun come from? Most scientists believe that the sun, the earth, and the other planets were once part of the same material.

UNDERSTANDING THE SUN'S IMPORTANCE

Look at Figures A through D and answer the questions with each.

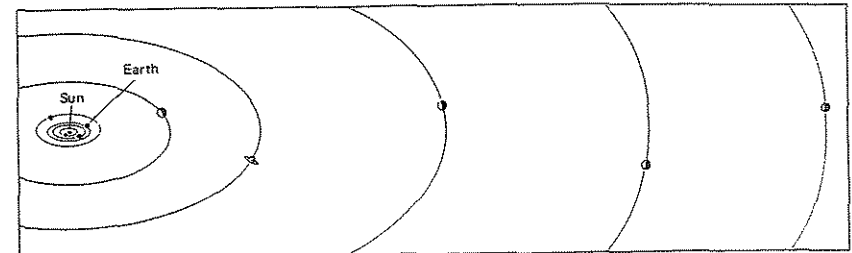


Figure A

The planets move around the sun. The sun keeps them in their paths, or orbits.

1. Would the earth stay in orbit without the sun? _____
2. Do scientists think the planets came from the same material as the sun? _____

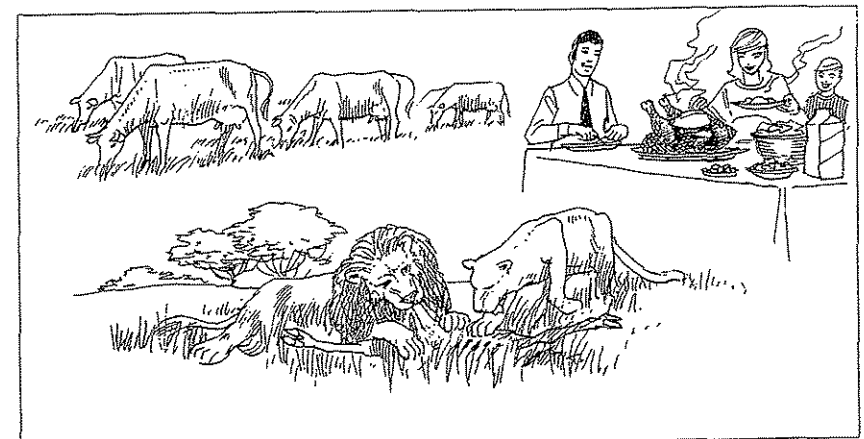


Figure B

All food may be traced back to the sun. Plants need the sun's energy to make food. Animals eat the plants. Then we eat plants and animals.

3. Could there be life without food? _____
4. Plants give us food. What else do they provide to the air we breathe? _____



Figure C Coal was formed by giant plants millions of years ago.

5. Would we have coal if there were no sun? _____
6. Coal is a fuel. We burn fuel for its energy. What are two other fuels?

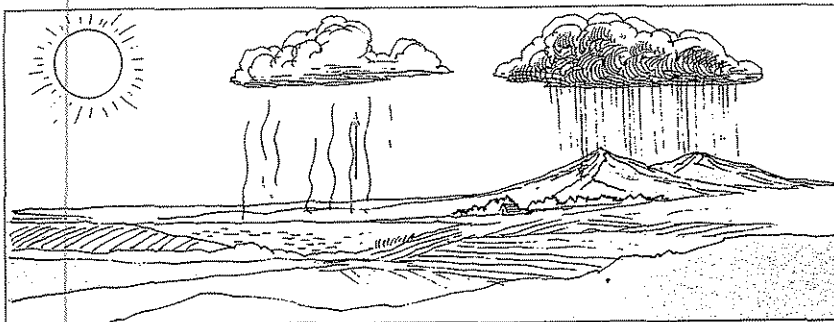


Figure D Water from the earth evaporates. It forms clouds. The clouds give us rain.

7. What causes the earth's water to evaporate? _____

8. Could there be a water cycle without the sun? _____

COMPLETING SENTENCES Complete the sentences with the choices below. One of these may be used twice.

plants
water cycle
gas
oxygen

food
oil
fuel

sun
coal
planets

1. There can be no life without the _____.
2. Plants give us _____ and _____.
3. Meat is really changed-over _____.
4. Any substance we burn for energy is called a _____.
5. Three common fuels are _____, _____, and _____.
6. Coal, oil, and gas would not have formed if it weren't for the _____.
7. The change of liquid water to water vapor and then back to liquid water is called the _____.
8. Scientists believe that the sun and the _____ came from the same material.

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|----------------------|---|
| 1. _____ oxygen | a) evaporation, then rain—over and over again |
| 2. _____ water cycle | b) burned for its energy |
| 3. _____ fuel | c) caused by the sun's heat |
| 4. _____ orbit | d) given off by plants |
| 5. _____ wind | e) path |

REACHING OUT

Vitamins are important to health. Sunlight helps the body to make one kind of vitamin. In fact, it is called the "sunshine vitamin." Which vitamin is this? _____

WORD SEARCH The words in the list are hidden in the groups of letters. Try to find each word. Draw a line around the word. The spelling may go in any direction: up-and-down, across, or diagonally.

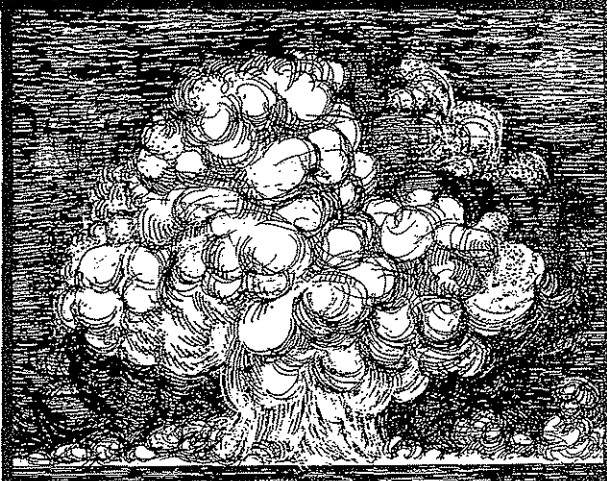
STAR
ASTRONOMY
SATELLITE
SPECTRUM
MAGNIFY
ORBIT
ANGLE
MIRROR
PARALLAX
MOON
TELESCOPE
ASTRONOMER
SPACE AGE
LENS

A	E	P	O	C	S	E	L	E	T
I	S	A	T	E	L	L	I	T	E
M	R	T	S	A	E	L	N	A	O
E	M	U	R	T	C	E	P	S	R
G	N	N	O	O	M	B	T	I	B
A	S	T	R	O	N	O	M	E	R
E	M	M	G	X	R	O	A	P	E
C	Y	F	I	N	G	A	M	I	L
A	G	S	N	R	A	T	S	Y	G
P	S	T	N	O	R	B	I	T	N
S	B	A	A	E	A	O	A	N	A
S	A	X	A	L	L	A	R	A	P

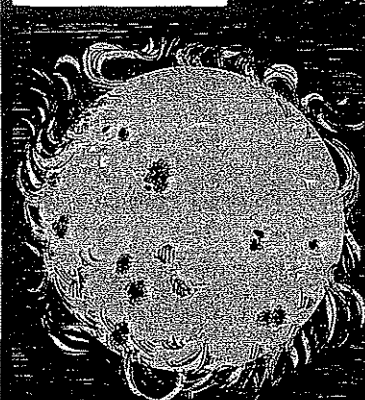
HOW DOES THE SUN GET ITS ENERGY?

$${}^2\text{H} + {}^3\text{H} \rightarrow {}^4\text{He} + \text{energy}$$

10



fusion: the joining together of hydrogen atoms to form helium atoms



AIM | How does the sun gets its 10 energy?

What is the sun? Most people would say "a ball of burning gases." Well, this is not entirely correct. The sun is made up of gases. But they are not burning. They are glowing. The gases give off light because they are so hot. In fact, anything that is hot enough glows.

Burning is a kind of chemical reaction. It is the linkup of oxygen with another substance. This linkup is not happening on the sun. No burning can take place on the sun. There are two reasons:

1. The sun does not have enough oxygen.
2. Strange as it seems, the sun is just too hot for burning to take place.

The reaction that gives the sun its energy is called nuclear fusion. Nuclear fusion joins or fuses the nuclei of atoms. This produces different kinds of atoms.

The sun is about 70% hydrogen. Part of this hydrogen changes into helium by fusion.

A single reaction fuses four hydrogen atoms. This produces one helium atom. However, about 1% of the hydrogen does not become part of the new helium atom. It changes into heat energy.

Each fusion reaction produces only a small amount of heat. But an enormous number of fusions take place. An enormous amount of hydrogen changes to helium. A great deal of heat energy is given off.

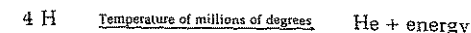
Every second, about 500 million metric tons of hydrogen change to 495 million metric tons of helium. The remaining 5 million metric tons change to energy.

This adds up to a tremendous amount of heat and light. This heat and light is our sun.

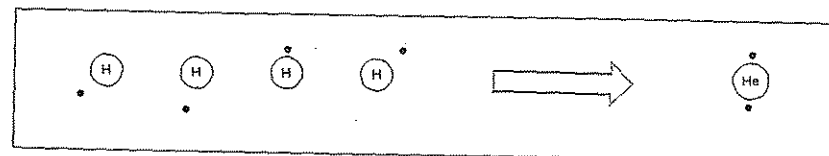
And remember, our sun is a star. Other stars get their energy the same way.

UNDERSTANDING HYDROGEN FUSION

This is a nuclear equation.



It tells us that four atoms of hydrogen fuse to form . . . one atom of helium—plus ENERGY.

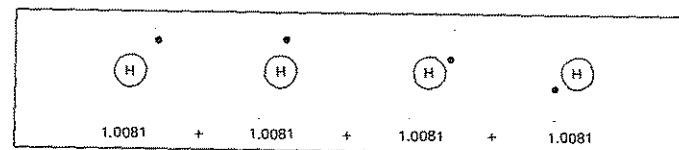


Question: Where does this energy come from?

Follow the explanation step-by-step.

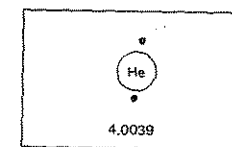
- ▣ The atomic weight of hydrogen is 1.0081.
- ▣ The atomic weight of helium is 4.0039.

Four hydrogen atoms weigh 4.0324



$$4 \times 1.0081 = 4.0324$$

One helium atom weighs 4.0039.



We see that one helium atom weighs .0285 less than four hydrogen atoms.

$$\begin{array}{r} 4.0324 \\ - 4.0039 \\ \hline .0285 \end{array}$$

▣ It is this matter that changes to energy.

- ▣ It is this energy multiplied trillions and trillions of times that gives our sun its heat and light.

SOME INTERESTING FACTS ABOUT THE SUN

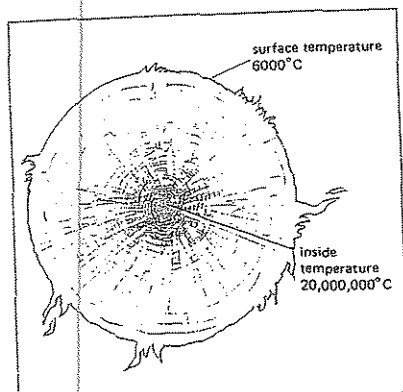


Figure A
Fusion takes place inside the sun's center.

Will the sun ever be used up? Yes! But not for a long, l-o-n-g time. The sun is so huge that it will keep on giving off heat and light for another billion years!!

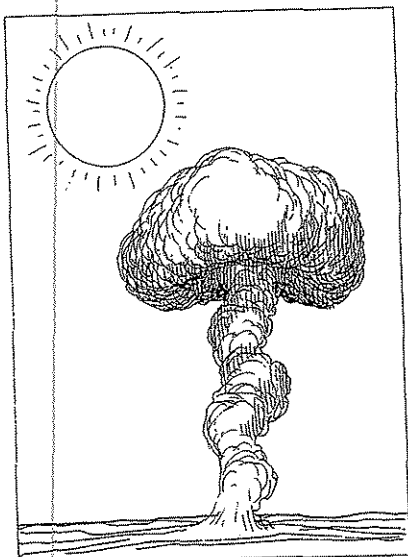


Figure B

Talk about diets! Every second, 5 million tons of the sun's hydrogen change to energy.

This means that the sun loses 5 million metric tons of weight every second.

How much weight does the sun lose in just one year? This is the number:

157,680,000,000,000

It stands for one hundred fifty seven trillion, six hundred eighty billion metric tons.

The energy from the hydrogen bomb comes from fusion—just like the sun's energy. But there is a difference.

- ▣ The sun's fusion does not take place all at once. It is spread out in time. So is the energy it gives off.
- ▣ The hydrogen bomb fuses all its material and releases all its energy at once—in just one millionth of a second!

COMPLETING SENTENCES Complete the sentences with the choices below.

burning
helium
hydrogen
chemical
light

four
nuclear
one
nuclei

joins
oxygen
heat energy
nuclear fusion

1. Burning is a _____ reaction in which _____ links up with another substance.
2. The energy from the sun is not caused by _____.
3. The sun gets its energy from _____ reactions.
one word
4. The kind of nuclear reaction that gives the sun its energy is called _____.
5. Fusion _____ the _____ of atoms.
6. The sun is made up mostly of _____.
7. Fusion on the sun joins atoms of hydrogen. _____ hydrogen atoms fuse to form _____ atom of helium.
8. _____ is nearly four times heavier than hydrogen.
9. About 1% of the hydrogen does not become helium. It changes to _____.
10. Anything that becomes hot enough gives off _____.

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|---|--|
| 1. _____ fuse | a) give the sun its energy |
| 2. _____ nuclear fusions | b) nearly four times heavier than hydrogen |
| 3. _____ hydrogen | c) about 70% of the sun |
| 4. _____ $4\text{ H} \rightarrow \text{He} + \text{energy}$ | d) join |
| 5. _____ helium | e) nuclear fusion equation |

REACHING OUT

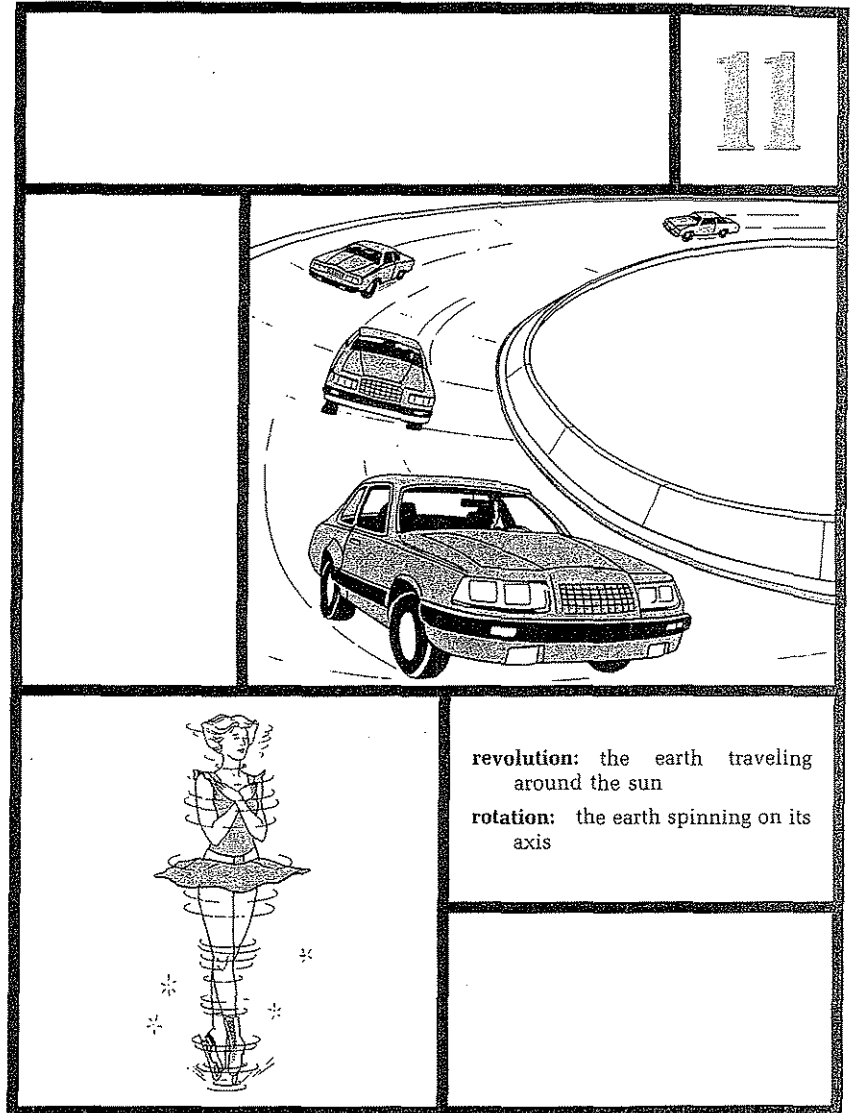
Nuclear fusion like that which happens on the sun, is also called *thermonuclear fusion*. Why?

WORD SCRAMBLE Unscramble each of the following to form a word or term that you have read in this Aim.

1. SIFONU
2. MILUHE
3. GEENYR
4. RANLUCE
5. GRODHENY

WHAT ARE THE EARTH'S MOTIONS?

11



revolution: the earth traveling around the sun

rotation: the earth spinning on its axis

AIM 11 | What are the earth's motions?

Find a quiet place where you can be alone for a few minutes. It can be anywhere—in your room, your yard, a park, or a vacant lot or field. Just as long as you can look around and observe what's happening.

What is happening? If your answer is "nothing," think again. In the minute or so that you have been looking around, the spot you are standing on has moved. It has traveled a distance of about 17 kilometers (10 miles)! In 24 hours, that same spot will have traveled a circular distance of more than 25,000 kilometers (15,000 miles)!

And that's not all. While you are looking around, you are traveling through space. You are moving at a speed of about 30 kilometers (18 miles) per second!

How can this be? How can you be moving and not feel it? Or see it? The reason you can't sense the motion is because everything around you is moving too. Your home, the trees, the air and clouds—everything is moving at the same speed.

Actually, the entire earth is moving. In fact, there are two different motions of the earth. Both are happening at the same time.

First, the earth is "spinning like a top." It is turning, or rotating, on its axis. This motion is called rotation (roh TAY shun). It takes the earth 24 hours to complete one rotation. This time period is called a day.

Second, the earth is moving through space. It is traveling, or revolving, around the sun. This motion is called revolution (rev uh LOO shun). The earth completes one revolution in 365¼ days. This time period is called a year.

THE EARTH'S ROTATION

You can't feel it, but the earth is spinning on its axis. It rotates from west to east. You may think, "So what? If I can't feel it spinning, what difference does it make?"

Let's take a quick look at the "difference" rotation makes. Look at drawings A, B, and C.



Rotation causes the sun to rise in the east and set in the west.

Rotation causes the stars to move across the sky at night.

Rotation affects wind direction.

You will learn more about the earth's rotation in Aim 13.

THE EARTH'S REVOLUTION

In one year, the earth travels about 940,000,000 kilometers! It revolves around the sun. You can't feel this motion either. But there are ways to tell the earth revolves. Look at drawing D.

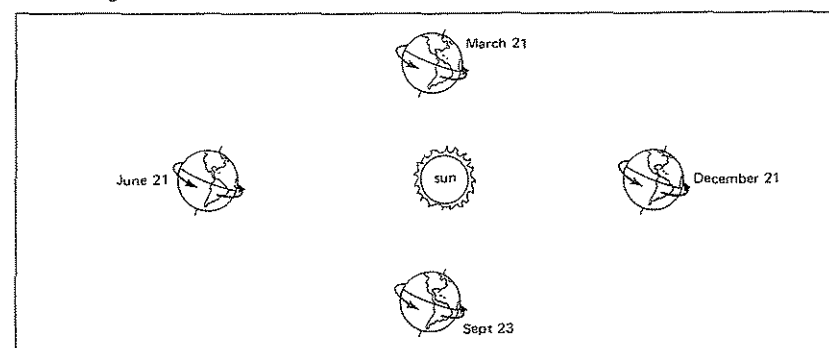


Figure D

The drawing shows the earth at different points in its trip around the sun. Notice the dates. At each of these dates, we start a different season. The earth's revolution (along with the tilt of its axis) causes the seasons.

ROTATION OR REVOLUTION?

Each statement describes something caused by one of the earth's motions. Beside each statement, write the word rotation or revolution.

1. _____ The sun sets in the west.
2. _____ The "big dipper" moves across the sky.
3. _____ The leaves turn from green to red.
4. _____ The sun is right overhead at noon.
5. _____ Flowers burst into bloom.

REACHING OUT

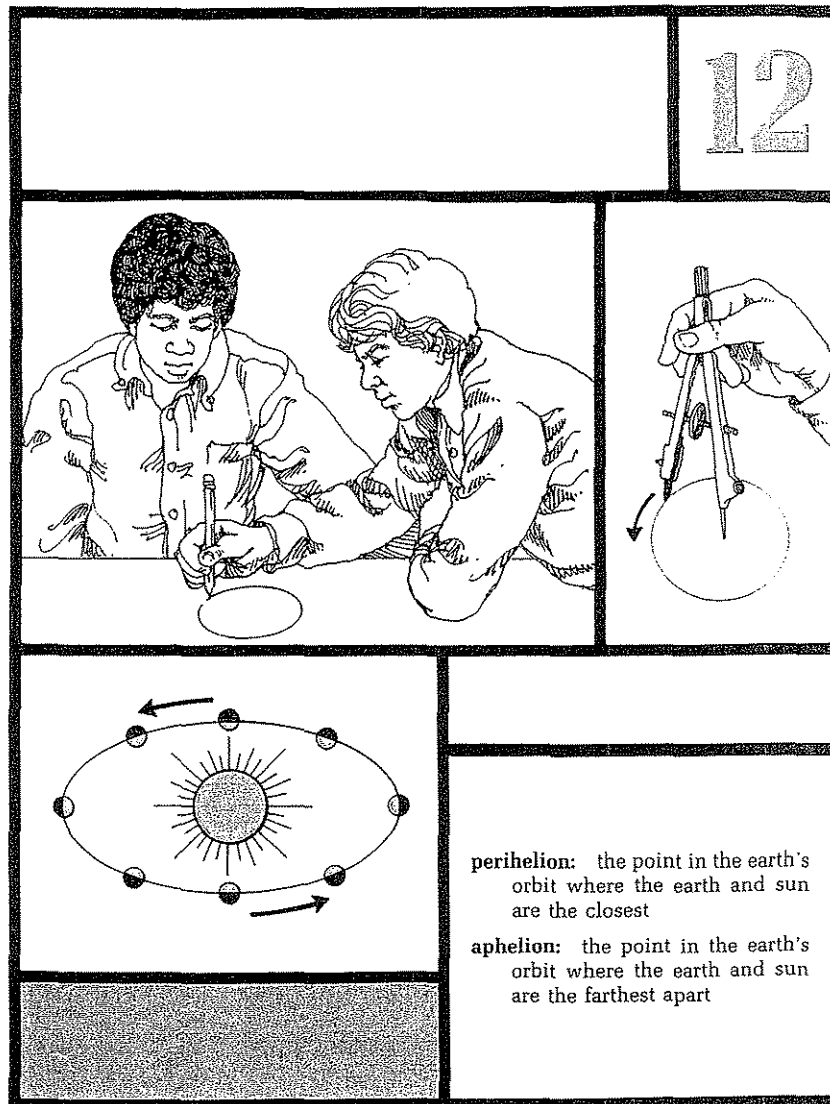
Look at the two drawings on page 57. Tell which of the earth's motions—rotation or revolution—each picture shows. Explain your answer.

Skater: _____

Race cars: _____

WHAT IS THE SHAPE OF THE EARTH'S ORBIT?

12

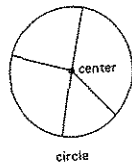


AIM | What is the shape of the 12 earth's orbit?

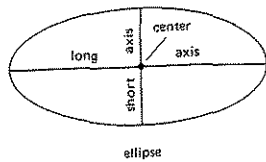
Look at Figure A on the facing page. By now, you know it well. It shows the earth's orbit around the sun.

Notice that the earth's orbit is not in the shape of a circle. The earth's orbit is slightly oval-shaped. This shape is called an ellipse.

What is the difference between a circle and an ellipse?



In a circle, the distance from the center to any point along the edge is the same.



In an ellipse, the distance from the center to the edge changes as you move along the edge.

An ellipse has a long axis and a short axis. They cross at right angles at the center of the ellipse.

The earth's orbit is an ellipse. And the sun is not exactly in the center of the ellipse. It is slightly off center. For these reasons, the earth is not the same distance from the sun at all times.

About January 2, the earth is closest to the sun. It is about 147 million kilometers away. The point in the orbit that is closest to the sun is called the perihelion [peh ree HEEL ee un].

About July 3, the earth is farthest from the sun. It is about 152 million kilometers away. The point in the orbit that is farthest from the sun is called the aphelion [u FEEL ee un].

All the planets—not just the earth—orbit the sun in elliptical paths.

THE EARTH'S ORBIT AROUND THE SUN

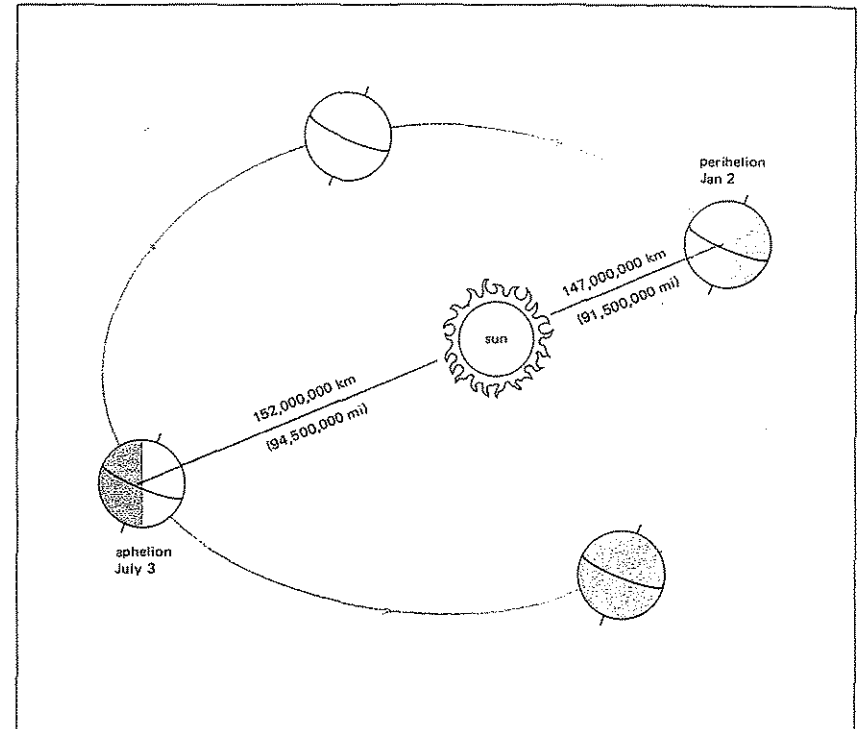


Figure A

1. What is the shape of the earth's orbit? _____
2. Is the sun in the center of the orbit? _____
3. Is the earth the same distance from the sun along the entire orbit? _____
4. a) How far is the earth from the sun about January 2? _____
b) This is the earth's _____ distance from the sun.
closest, farthest
c) What do we call this point of the earth's orbit? _____
5. a) How far is the earth from the sun about July 3? _____
b) This is the earth's _____ distance from the sun.
closest, farthest
c) What do we call this point of the earth's orbit? _____

THE PLANETS AND THEIR ORBITS

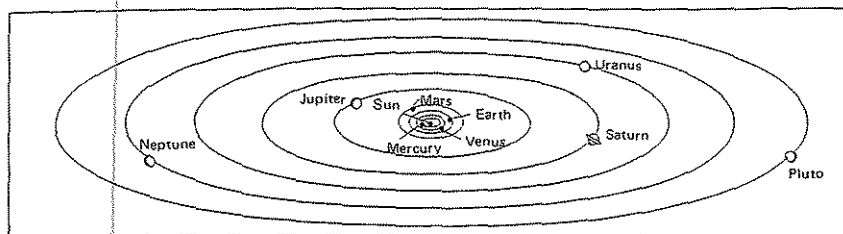


Figure B

1. How many planets orbit the sun? _____
2. Name the planets in order. Start with the closest planet. _____

3. What shape is the orbit of every planet? _____

Scientists have found that:

- The closer a planet is to the sun, the faster it moves.
- The farther it is, the slower it moves.

The speed of a planet's orbit is called its orbital velocity.

4. a) Which planet has the slowest orbital velocity? _____
b) Why? _____
5. a) Which planet has the fastest orbital velocity? _____
b) Why? _____

A planet moves at different speeds at different points of its orbit. The speed depends upon how close or far away from the sun the planet is.

Look back at Figure A on page 63.

6. a) On which date does the earth move the fastest? _____
b) Why? _____
7. a) On which date does the earth move the slowest? _____
b) Why? _____

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|----------------------|--|
| 1. _____ ellipse | a) closest point of an orbit |
| 2. _____ all planets | b) all lines from center to edge are equal in size |
| 3. _____ circle | c) farthest point of an orbit |
| 4. _____ aphelion | d) have ellipse-shaped orbits |
| 5. _____ perihelion | e) oval |

TRUE OR FALSE Write T on the line next to the number if the sentence is true. Write F if the sentence is false.

1. _____ The planets move in circular orbits around the sun.
2. _____ The sun is in the very center of the earth's orbit.
3. _____ The earth is at the same distance from the sun at all times.
4. _____ The earth's orbital velocity changes as it moves around the sun.
5. _____ Aphelion is the closest point of an orbit.
6. _____ Perihelion is the closest point of an orbit.
7. _____ The earth is at aphelion in July.
8. _____ The earth is closest to the sun in July.
9. _____ The closer a planet is to the sun, the faster it moves.
10. _____ The orbital velocity of Pluto is faster than the orbital velocity of Earth.

TRY THIS!

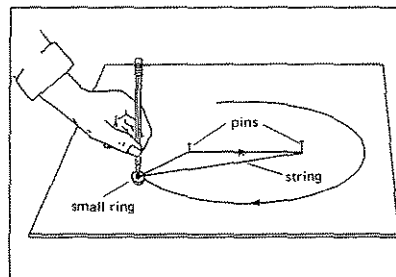


Figure C

You can make an ellipse easily. Figure C shows how to do it.

Make a few ellipses at home.

Try using different string lengths and different pin positions.

KEEPING UP WITH SCIENCE

VISITORS WITH LONG SHINING TAILS

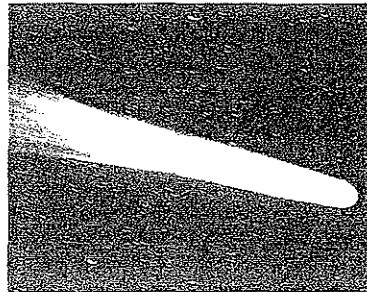
We all know what a comet looks like. But what are comets? Where do they come from? What are they made of?

Scientists believe that comets are made of chunks of frozen water, frozen methane and ammonia gases, as well as dust particles. They may be left over from the formation of our solar system.

Comets are a rare sight to us earthlings. However, Jan Oort, a Dutch astronomer, feels there could be as many as 100 billion of these space objects. They are located where they were formed—in the deep freeze of the outer edges of our solar system—trillions of miles from our sun. There they remain moving in huge orbits.

Sometimes, the gravity of a passing star sends some comets moving towards our sun. Some of them crash onto a planet, including Earth. Others collide with the sun. A few are trapped by the gravity of a planet. They go into orbit between that planet and the sun. The path may take a comet far beyond the sun.

As a comet nears the sun, it is heated. The frozen gases in its head begin to vaporize. Together with dust particles, the gases form a cloud called the coma. Part of the coma surrounds the head. The rest is pushed outward by the pressure of radiation and charged particles coming from the sun. This produces a long tail. It can measure millions of miles in length. The tail



always points away from the sun's wind of charged particles. The sun's energy makes it glow.

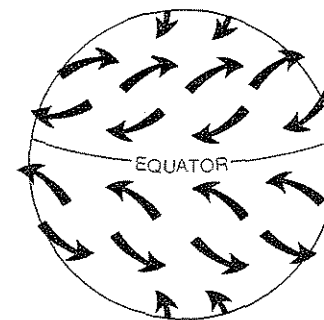
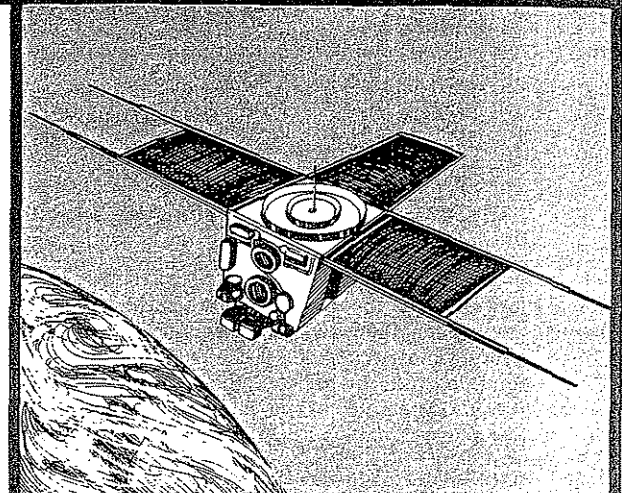
As a comet moves back into deep space, the vapors cool and freeze again. Most of the material of the coma and tail moves back into the head. As a result, the comet loses its tail. It reforms when the comet nears the sun again on its next fly-by. Only about 1 percent of a comet's material is lost during each passing.

The most famous comet is Halley's comet. It visits our planet every 76 years. Its last visit was in 1986. This visit was not nearly as spectacular as the one it made in 1910, when the earth is believed to have passed through the comet's tail. This is not as dangerous as it sounds. The tail is made up of glowing gases and is over 80 million kilometers long.

Halley's comet is due back in 2062. It is hoped that the next visit will be more like the 1910 visit. However, scientists are excited about the next visit. They are already making plans about the best ways to study the comet. After all, when a "visitor" only calls once every 76 years, it pays to be ready.

HOW DO WE KNOW THAT THE EARTH IS ROTATING?

13



deflect: shift

star trails: pictures showing the movement of stars

AIM | How do we know that the 13 earth is rotating?

Get ready for a surprise! At this very moment you are moving in a circle. You are speeding along at about 1,250 kilometers (775 miles) per hour.

It seems impossible. But it's true! You are moving because the earth is moving. The earth rotates on its axis. And everything on earth rotates along with it—including you!

How do we know that the earth is rotating? We can't feel the movement. But several clues prove that the earth is rotating:

CLUE #1 If the earth did not rotate, there would be no change from day to night. One half of the earth would have only day. The other half would have only night.

CLUE #2 The sun, moon, and stars seem to move across the sky. They seem to move because the earth is rotating.

CLUE #3 Planetary winds are winds that move across large parts of the earth. They are caused mainly by the uneven heating of the earth's surface. Planetary winds would be straight blowing winds if the earth did not move. The earth's rotation shifts or deflects them. The winds curve from their paths.

CLUE #4 We know that the earth's shape is not exactly round. It bulges slightly at its middle.

What could explain this bulge? Again, the earth's rotation. When the earth rotates it causes an outward force. This outward force causes the earth to be bigger around the middle.

CLUE #5 Many artificial satellites have orbited the earth. Several are in orbit now. A satellite is in a different position at the end of each orbit. It shifts a bit to the west. But actually it is not the satellite that shifts. It just seems that way.

The satellite seems to shift because the earth moves towards the east as it rotates. The satellite seems to move in the direction opposite to the way the earth rotates.

UNDERSTANDING THE CLUES

Clue #1 Look back to Aim 11.

1. The changes from day to night are caused by the earth's rotation, revolution.

Clue #2 Look at Figure A on this page.

2. What heavenly bodies are moving across the sky? _____
3. What makes them seem to move across the sky this way? _____

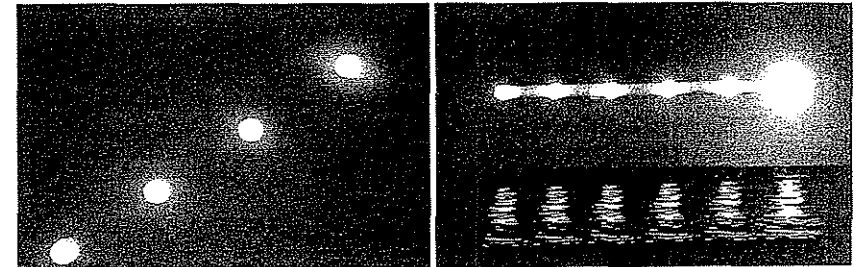


Figure A

The northern end of the earth's axis always points to the North Star. As the earth rotates, the stars appear to move in a circle around the North Star.

Figure B is a photo of the sky at night. It was taken at the northern end of the earth's axis.

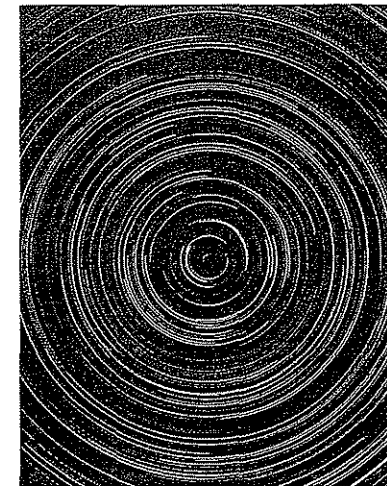


Figure B

The camera was pointed at the North Star. Light was allowed to enter the camera for about eight hours.

The streaks of light are called star trails. They trace the paths stars seem to take.

These star trails are the paths of the stars that surround the North Star.

4. What is the shape of these star trails? _____
5. Were the stars moving in circles? _____
6. What was moving in a circle? _____

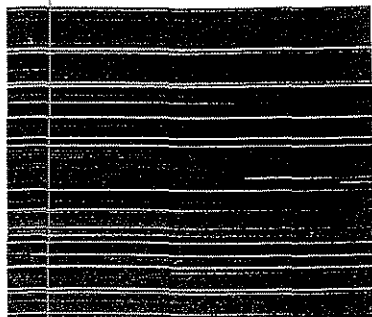


Figure C

Clue #3

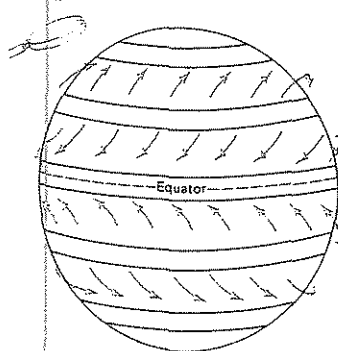


Figure D

Clue #4

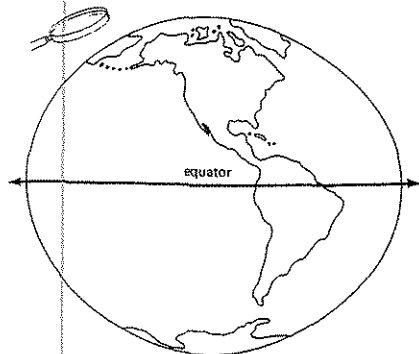


Figure E

7. Take a guess. Where do you think the star trails in Figure C were taken from? _____

The arrows in Figure D stand for the planetary winds.

8. What is the main cause of planetary winds? _____
9. Planetary winds curve. What makes them curve? _____

Look at Figure E.

10. Is the earth exactly round? _____
11. Which part bulges slightly? _____
12. Spinning builds an outward force.
- a) Does the earth spin? _____
- b) What do we call the earth's spin? _____
13. What causes the earth to bulge slightly at the equator? _____

Clue #5

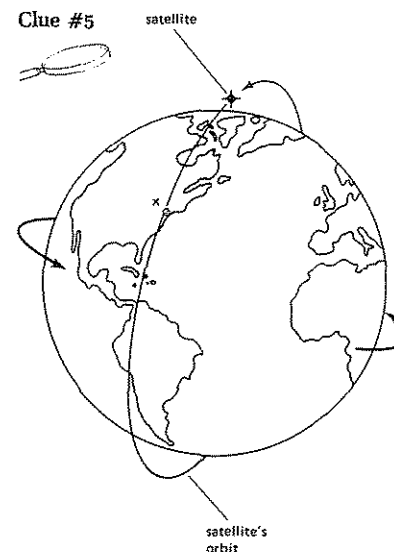


Figure F

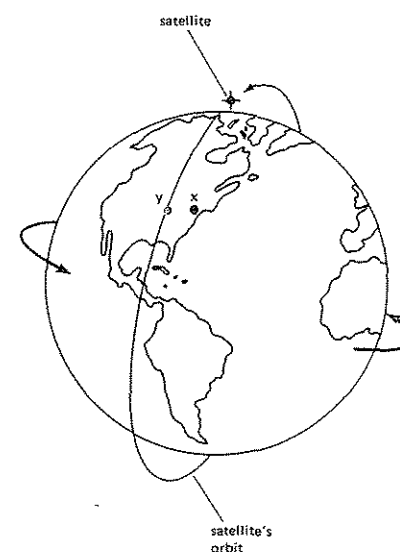


Figure G

Figure F shows an artificial satellite orbiting the earth. Figure G shows the same satellite after one orbit.

14. At which position is the satellite in Figure F? _____
x, y
15. At which position is it after one orbit? _____
x, y
16. Position y is _____ of position x.
east, west
17. Underline the correct statement.
- a) The satellite moved from x to y.
- b) The earth moved from x to y.
18. In which direction does the earth rotate? _____
east to west, west to east
19. In which direction does the satellite seem to have moved? _____
east to west, west to east
20. A satellite seems to move in _____ direction of the earth's rotation.
the same, the opposite
21. The "apparent" shift of orbiting satellites proves two things. What are they?

COMPLETING SENTENCES Complete the sentences with the choices below.

moon
24
shift to the west
curve

outward
sun
spinning

night
bulge
stars

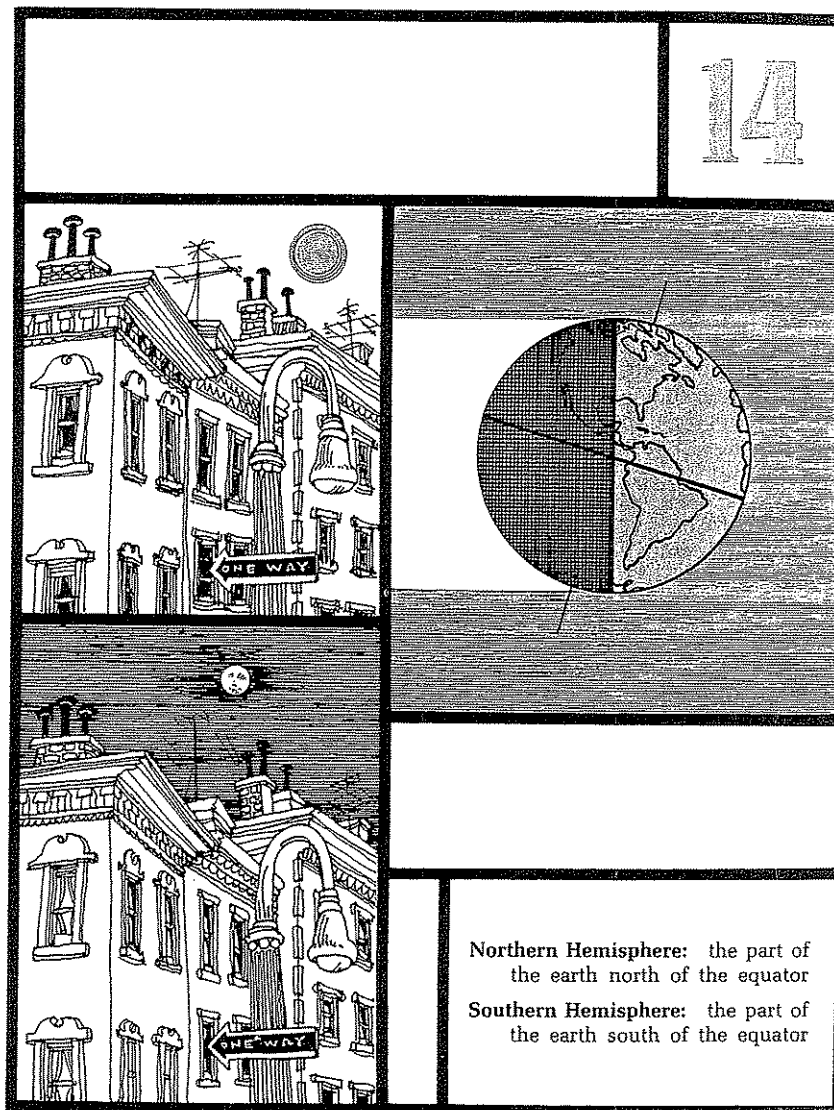
1. Rotation is a _____ motion.
2. The earth rotates on its axis once every _____ hours.
3. The earth's rotation causes day to change to _____.
4. The earth's rotation causes the _____, _____, and _____ to seem to move across the sky.
5. The earth's rotation cause planetary winds to _____.
6. A rotating object builds an _____ force.
7. The earth's rotation causes the earth to _____ at the equator.
8. The earth's rotation causes satellites to seem to _____.

TRUE OR FALSE Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

1. _____ The earth rotates from east to west.
2. _____ The earth rotates once every year.
3. _____ The tilt of the earth's axis never changes.
4. _____ The northern end of the earth's axis always points to the North Star.
5. _____ The North Star seems to move in a circle.
6. _____ Stars surrounding the North Star move in circles around the North Star.
7. _____ The earth's rotation causes planetary winds.
8. _____ The earth's rotation shifts the planetary winds.

WHAT CAUSES DAY AND NIGHT?

14



Northern Hemisphere: the part of the earth north of the equator
Southern Hemisphere: the part of the earth south of the equator

AIM | What causes day and night? 14

Usually when you go to sleep, it is dark. You wake up the next morning, and it is light. Several hours will pass and day will change to night again.

What causes day and night? The changes of day and night are caused by the earth's rotation.

As the earth rotates, only one half faces the sun at any given time. The half that is facing the sun has day. The opposite side (the side that is facing away from the sun) has night.

As the earth rotates, new parts face the sun. Places that have night slowly turn to day. One complete rotation of the earth takes 24 hours. In most places, therefore, one change from night to day and then back to night again takes 24 hours.

How many of these 24 hours are night? How many are day? It depends upon two things: the time of year, and how far from the equator a place is.

If the earth's axis were vertical (straight up and down), all parts of the earth would have 12 hours day and 12 hours night all year round. But, the earth's axis is not vertical. The earth's axis is tilted $23\frac{1}{2}$ degrees.

As the earth moves around the sun, the tilt of the earth does not change. The earth just changes its position compared to the sun. Sometimes the earth is tilted so that the northern portion of the earth is facing the sun. This makes the days longer than nights in the Northern Hemisphere.

When the earth moves to the other side of the sun, the southern portion of the earth is facing the sun. Now the days are longer than nights in the Southern Hemisphere.

How far north and south of the equator a place is, also affects how long day and night will be. The farther north and south of the equator a place is, the greater the difference in length there between day and night.

UNDERSTANDING DAY AND NIGHT

Study Figure A. Then answer the questions or fill in the blanks.

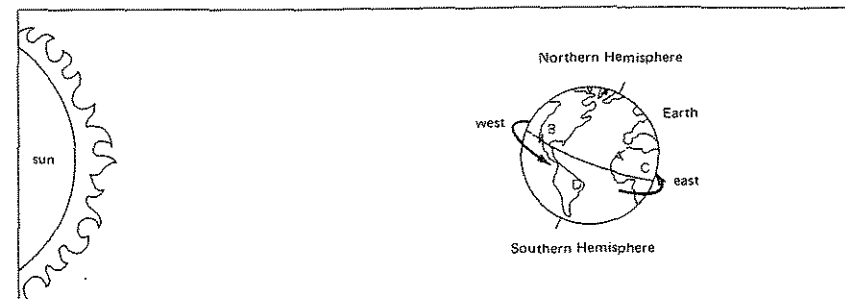


Figure A

- The earth turns on its axis. Another way of saying this is the earth _____ on its axis. revolves, rotates
- How many hours does one rotation of earth take? _____
- At any given time.
 - how much of the earth is facing the sun? _____
 - how much of the sun is facing away from the sun? _____
- The part of the earth facing the sun has _____ night, day.
- The part of the earth facing away from the sun has _____ night, day.
- The earth rotates from _____ east to west, west to east.
- A, B, C, and D are places on the earth.
 - Which of these places are having day? _____
 - Which of these places are having night? _____
- Of the places that are having day, which one will move into night first? _____
- Of the places that are having night, which one will move into day first? _____
- Which places are in the Northern Hemisphere? _____
 - Which place is in the Southern Hemisphere? _____

THE LONG AND THE SHORT OF IT

Study Figure B. Answer the questions or fill in the blanks.

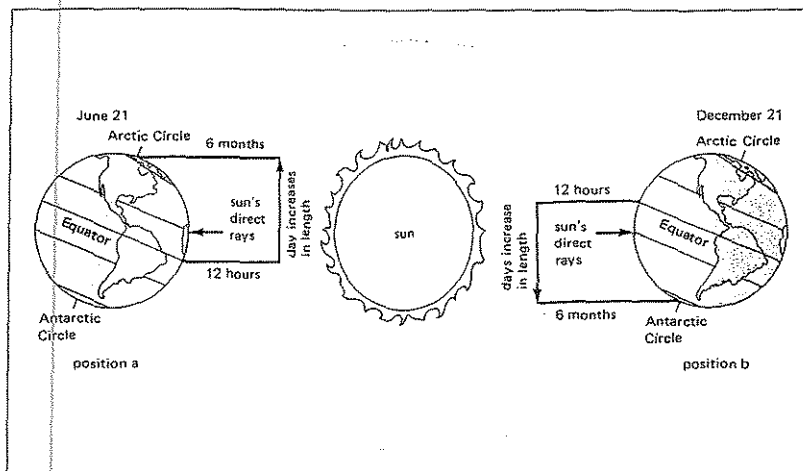


Figure B

Position a shows the earth on June 21.

Position b shows the earth six months later on December 21. It has now come halfway along its revolution around the earth.

- Look at the earth's axis on both dates. Has the angle of its tilt changed? _____
- Has the direction of the tilt changed? _____

3. On June 21 . . .

- the _____ Hemisphere tilts toward the sun.
Northern. Southern
- the _____ Hemisphere tilts away from the sun.
Northern. Southern

4. On June 21 . . .

- which hemisphere has more sunlight? _____
- which hemisphere has less sunlight? _____

- On June 21, days are longer in the _____ Hemisphere.
Northern. Southern
 - If days in the Northern Hemisphere are longer, then days in the Southern Hemisphere _____
are longer too. are shorter
- On June 21, which part of the earth has 12 hour days and 12 hour nights?

 - As you move farther north, the days become _____
longer. shorter
- How long does day last on June 21 at the Arctic Circle? _____
- When it is day at the Arctic Circle, it is _____ at the Antarctic Circle.

9. On December 21 . . .

the _____ Hemisphere leans toward the sun. The _____ Hemisphere leans away from the sun.
Northern. Southern Northern. Southern

- On December 21 . . .
 - which hemisphere gets more sunlight? _____
 - which hemisphere gets less sunlight? _____
- On December 21, days are longer in the _____ Hemisphere.
Northern. Southern
- If days in the Southern Hemisphere are longer, then days in the Northern Hemisphere are _____
longer too. shorter
- On December 21, which part of the earth has 12 hours day and 12 hours night?

- Does the length of day and night seem to change at the equator? _____
- How long does day last on December 21 at the Arctic Circle? _____
- When it is day at the Antarctic Circle, it is _____ at the Arctic Circle.

NOTE: Night and day at the Arctic and Antarctic Circles are not entirely dark or light for six complete months. Night changes very slowly to day. Day changes very slowly to night. It is mostly night for 6 months and mostly day for six months.

HOW LONG ARE DAY AND NIGHT ON MARCH 21 AND SEPTEMBER 23?

For most of the year, the number of hours of day and night in the Northern and Southern Hemispheres are unequal.

On just two days of the year, every place on earth has an equal number of hours of day and night.

On March 21 and September 23, neither hemisphere leans towards the sun. On these days, every place on earth has 12 hours day and 12 hours night.

Figure C shows the earth during one revolution around the sun. Study Figure C. Then answer the questions or fill in the blanks.

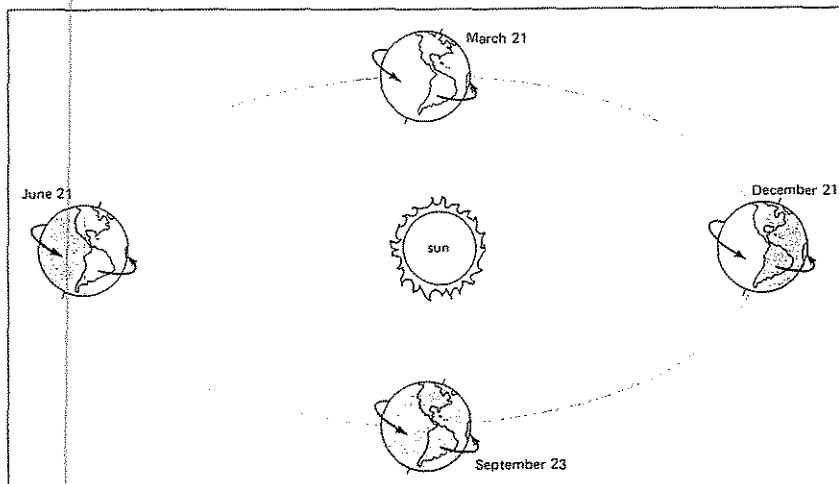


Figure C

- The earth _____ on its axis.
rotates, revolves
- The earth _____ around the sun.
rotates, revolves
- One rotation makes one _____.
day, year
- One revolution makes one _____.
day, year
- Figure C shows the earth at four different dates. Name these dates.

- Look at the earth's axis at each date.

- Has the angle changed? _____
- Has the axis changed the way it leans toward or away from the sun? _____

Name the Dates

- The Northern Hemisphere leans toward the sun most on _____.
 - The Northern Hemisphere leans away from the sun most on _____.
 - The earth's axis does not lean toward nor away from the sun on _____ and _____.
 - The longest day of the year in the Northern Hemisphere is _____.
 - The shortest day of the year in the Northern Hemisphere is _____.
 - Day and night are equal in length everywhere on earth on _____.
- In the Northern Hemisphere, between June 21 and September 23, days become _____.
longer, shorter
 - In the Northern Hemisphere, between September 23 and December 21, days become _____.
longer, shorter
 - In the Northern Hemisphere, between December 21 and March 21, days become _____.
longer, shorter
 - In the Northern Hemisphere, between March 21 and June 21, days become _____.
longer, shorter
- Differences in the number of hours of day and night happen _____.
slowly, suddenly
- In which hemisphere do you live? _____
 - What is today's date? _____
 - On this date, where you live, there will be more hours of _____.
day, night
 - Tomorrow, day will last a few minutes _____; night will last a few minutes _____.
shorter, longer

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|------------------------------------|---|
| 1. _____ earth's rotation | a) tilt of earth's axis |
| 2. _____ 23½° | b) fewest hours of night in the Northern Hemisphere |
| 3. _____ December 21 | c) day and night equal everywhere |
| 4. _____ June 21 | d) causes day and night |
| 5. _____ March 21 and September 23 | e) most daylight hours in the Southern Hemisphere |

REACHING OUT

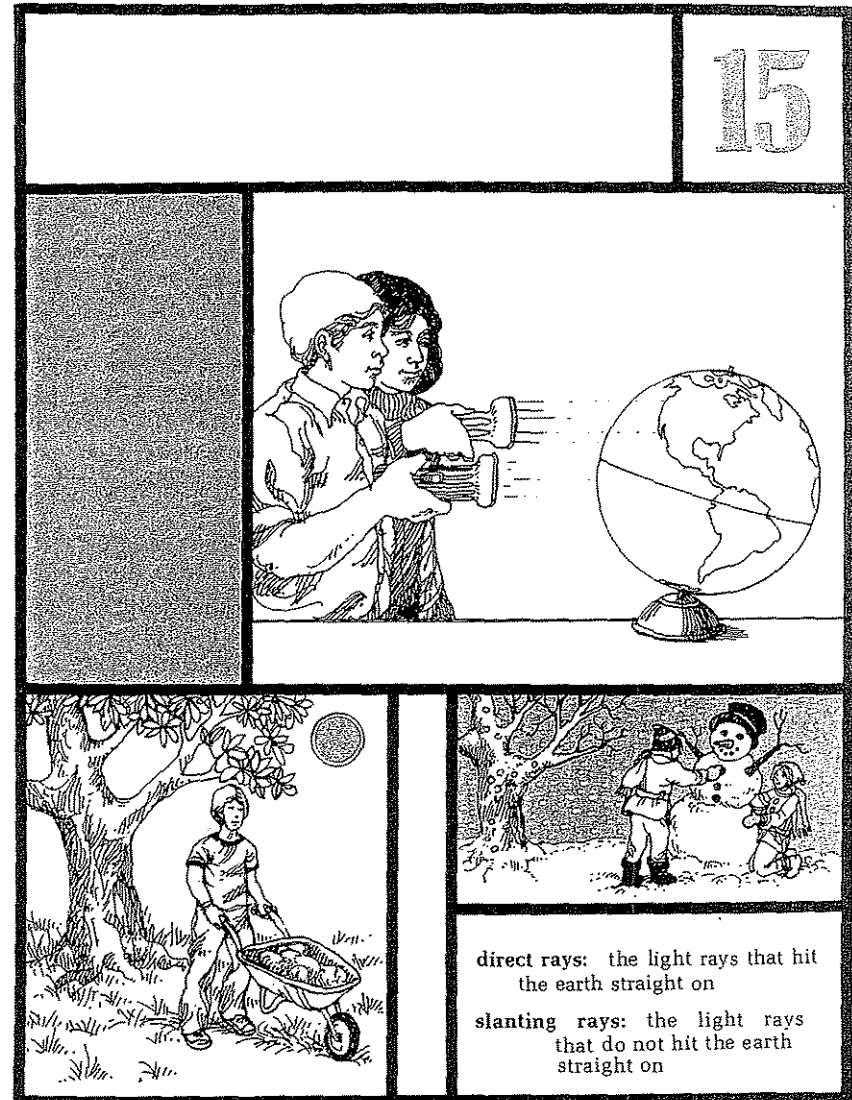
December 21 _____ March 21 _____

September 23 _____ June 21 _____

- What do we call these dates? Write the names next to the dates.
- These dates are not the same every year. Why do you think this is so? (Hint: What happens to our calendar every four years?) _____

WHAT CAUSES THE SEASONS?

15



AIM | What causes the seasons?

15

Are you ready for a vacation? Will you go swimming or will you go ice-skating? Of course, it all depends on the season.

Most people live in places that have four seasons—spring, summer, autumn, and winter.

The four seasons are marked by differences in temperature and in the lengths of day and night.

Summer, for example, is much warmer than winter. And summer days are longer than winter days.

What causes seasons? Seasons are caused by the earth's revolution around the sun and the unchanging tilt of the earth's axis.

You have already learned how the earth's axis causes differences in the lengths of day and night. The axis also causes differences in temperature.

Part of the year, the axis leans towards the sun. Part of the year, the axis leans away from the sun.

For example, June 21 is the first day of summer in the Northern Hemisphere. On that day, the Northern Hemisphere leans toward the sun the most. The sun's rays strike head-on or nearly head-on over a large part of this hemisphere.

Head-on, or direct, rays are strong rays. They do not spread over a large area. Direct rays heat up the earth the most.

December 21 is the first day of winter in the Northern Hemisphere. On that day, the Northern Hemisphere leans away from the sun the most. The sun's rays do not strike head-on. They spread over a large area. Rays that spread out are called *slanting* rays. Slanting rays are weak rays. They heat up the earth the least.

UNDERSTANDING DIRECT AND SLANTING RAYS

Figure A shows direct rays and indirect rays. Study it. Then answer the questions or fill in the blanks.

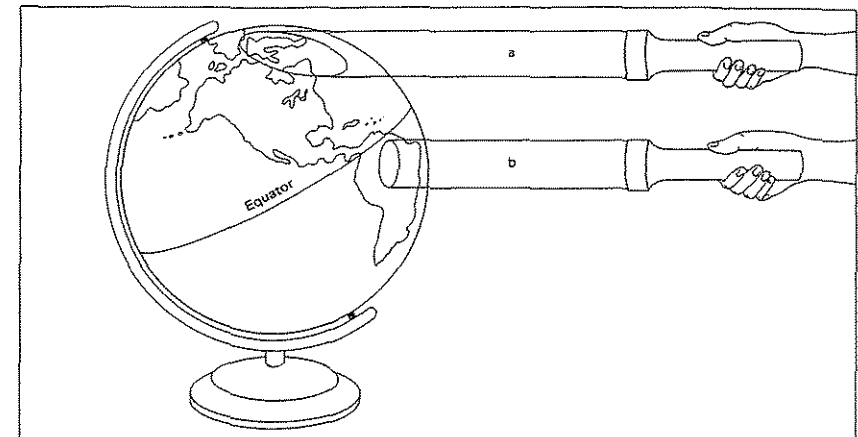


Figure A

1. Which rays are direct? _____
a. b

2. Which rays are slanting? _____
a. b

Answer direct or slanting:

3. Which rays spread out? _____

4. Which rays do not spread out? _____

5. Which rays are stronger? _____

6. Which rays are weaker? _____

7. Which rays heat a place more? _____

8. Which rays heat a place less? _____

9. Winter rays are _____ rays.

10. Summer rays are _____ rays.

11. Which of the rays of Figure A can stand for winter rays? _____
a. b

12. Which of the rays on Figure A can stand for summer rays? _____
a. b

UNDERSTANDING THE CHANGING SEASONS

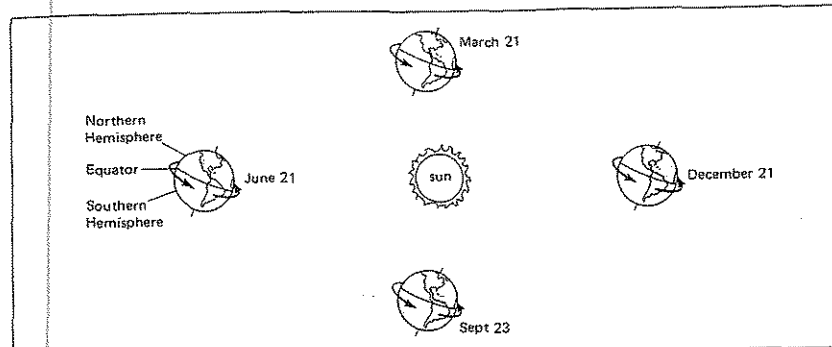


Figure B

TAKE A TRIP. Follow the earth for one revolution around the sun. Study Figure B. Then fill in the blanks.

- The earth revolves around the sun in a _____ direction.
clockwise, counterclockwise
- As the earth revolves around the sun, the earth's axis _____ change.
does, does not

3. On June 21, the Northern Hemisphere . . .

- faces _____ the sun.
toward, away from
- has mainly _____ weather.
cold, warm
- has _____ hours of daylight than the Southern Hemisphere.
more, fewer
- receives _____ rays. These are _____ rays.
direct, slanting strong, weak
- has the first day of _____.
name season

4. Between June 21 and September 22, the Northern Hemisphere still leans toward the sun. But every day . . .

- the lean becomes _____.
greater, less

- the rays become _____ direct and spread out _____.
more, less more, less
- the days become _____ and the nights become _____.
longer, shorter longer, shorter

5. On September 23 . . .

- the earth's axis is tilted _____ the sun.
toward, away from, neither toward nor away from
- the sun's rays are _____.
direct, slanting, neither direct or indirect
- _____ starts in the Northern Hemisphere.
name season
- every place on earth has _____ hours of day and _____ hours of night.

6. Between September 23 and December 20 . . .

- the Northern Hemisphere starts to lean _____ the sun.
toward, away from
 - the sun's rays become more _____. These rays are _____.
direct, slanting stronger, weaker
 - days become _____ and nights become _____.
longer, shorter longer, shorter
7. The Northern Hemisphere leans away from the sun the most on _____
give date
- which is the first day of _____.
name the season

8. Between December 21 and March 20 . . .

- the Northern Hemisphere leans away from the sun. But every day the lean becomes _____.
greater, less
- the rays become _____ slanting.
more, less
- the days become _____ and the nights become _____.
longer, shorter longer, shorter

9. On March 21 . . .

- the earth's axis is tilted _____ the sun.
toward, away from, neither toward nor away from
- the sun's rays are _____
direct, slanting neither direct nor indirect
- _____ starts in the Northern Hemisphere.
name the season

10. After March 21 . . .

- the Northern Hemisphere starts to lean _____ the sun.
toward, away from
 - the rays become more and more _____
direct, slanting
 - the rays become _____
stronger, weaker
 - the days become _____ and the nights become _____
longer, shorter longer, shorter
11. In the Northern Hemisphere, the number of daylight hours is greatest on _____;
give date; this is the first day of _____

CONGRATULATIONS! YOUR TRIP AROUND THE SUN IS NOW COMPLETE!

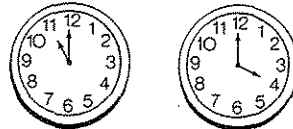
12. How long did your trip take? _____

REACHING OUT

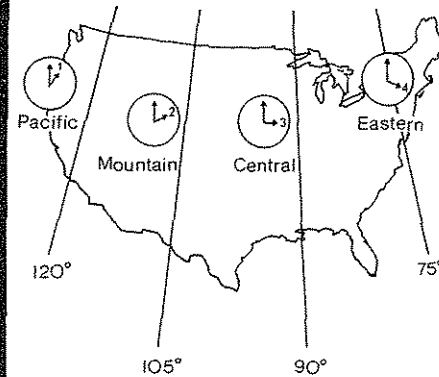
Record-breaking temperatures rarely happen on the first day of summer. It is usually the later months of summer that have the hottest weather. Why? _____

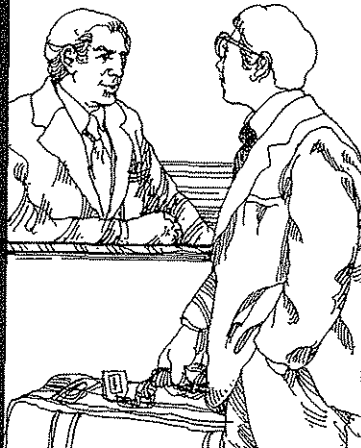
WHY IS THE TIME DIFFERENT AROUND THE WORLD?

16



NEW YORK LONDON





prime meridian: the imaginary line that runs north and south through Greenwich, England

international date line: the imaginary line that runs north and south and separates one day from the next

AIM | Why is the time different 16 around the world?

When it is 12 noon in New York, it is three hours earlier, (9 a.m.) in California. At the same moment in London, England, it is five hours later (5 p.m.).

Pearl Harbor, Hawaii, was attacked on December 7, 1941. But in Tokyo, Japan, it was December 8—one day later.

Why is the time different around the world?

Time depends upon the earth's rotation. The earth rotates from west to east once every 24 hours. As it rotates, the sun seems to move from east to west.

Because of this, places in the east see the sun *before* places in the west.

- It is later in the day in places that have already seen the sunrise.

- It is earlier in places that are waiting to see the sun.

New York, for example, is east of California. The sun rises in New York three hours before it rises in California. California must still wait three hours for the sun to rise. Therefore, it is three hours earlier in California than it is in New York.

How do we know how many hours difference there are between places?

The earth is divided into 24 standard time zones. They are imaginary lines that run north and south. The starting line is called the *prime meridian*. Distance between zones is measured in degrees east or west of the prime meridian.

There is one hour difference between each time zone. For each zone to the east, you add one hour. For each zone to the west, you subtract one hour.

Here's an example. If it is 10 a.m. where you live, then the time in the zone just to the east is 11 a.m. The time zone just to the west is 9 a.m.

UNDERSTANDING THE PASSING OF TIME

Study Figure A. Then answer the questions or fill in the blanks. A through F stand for different places.

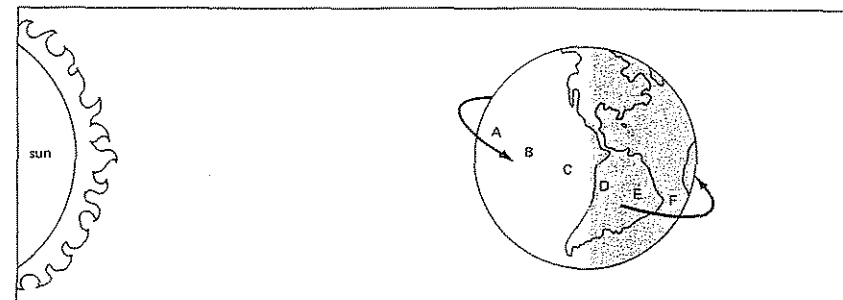


Figure A

- List the places that are having day: _____
- Which place had day first? _____
- Which place had day last? _____
- In which direction does the earth rotate? _____
west to east, east to west
- As you go to the west, the time becomes _____.
earlier, later
- As you go to the east, time becomes _____.
earlier, later
- B is _____ of C. The time at B is _____ than the time at C.
east, west earlier, later
- B is _____ of A. The time at B is _____ than the time at A.
east, west earlier, later
- List the places that are having night: _____
- Which place had night first? _____
- Which place had night last? _____
- E is _____ of D. The time in E is _____ than the time in D.
east, west earlier, later
- E is _____ of F. The time at E is _____ than the time at F.
east, west earlier, later
- Of all the places in the diagram, where is it the earliest? _____
Where is it the latest? _____

UNDERSTANDING TIME ZONES

Figure B shows the meridians. Study Figure B. Then answer the questions or fill in the blanks.

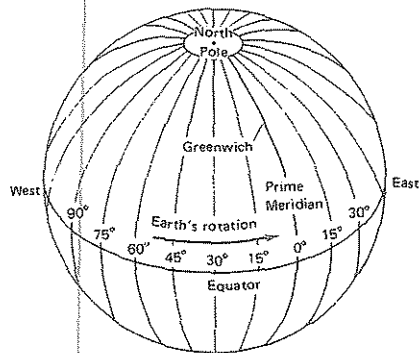


Figure B

The meridians in Figure B are straight lines. The distances between meridians are all the same. But the time zones do not look this way.

Most time zones are not straight lines. They zigzag in order to keep certain related places within the same time zone.

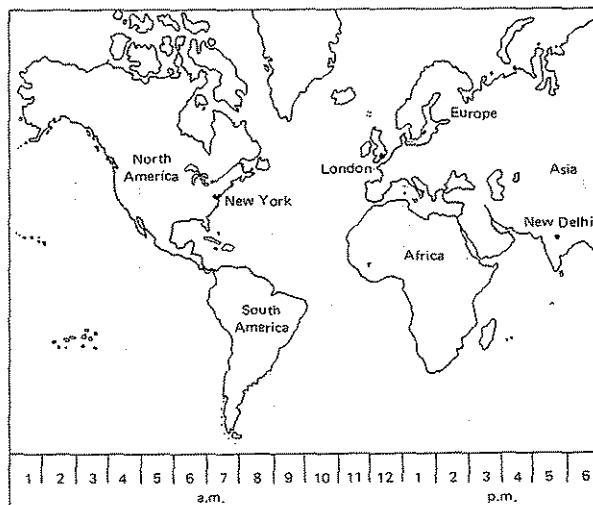


Figure C

A partial map of the time zones

1. Meridians travel _____
_____ parallel with the equator
2. The prime meridian passes through what city in England?

3. Distance between meridians is measured in degrees (°). How many degrees are there between meridians? _____

4. New York is _____ of the prime meridian.
_____ east, west
5. How many hours difference is there between London and New York? _____
6. The time in London is _____ than the time in New York.
_____ earlier, later
7. When it is 2 p.m. in New York, what time is it in London? _____
8. When it is 6 a.m. in London, what time is it in New York? _____
9. When it is 1 p.m. in London, what time is it in New Delhi? _____
10. When it is 12 noon in New Delhi, what time is it in London? _____

NORTH AMERICA'S TIME ZONES

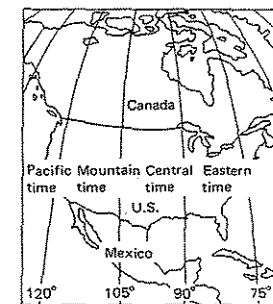


Figure D

Figure D shows most of North America. It is divided into four time zones. Study the figure. Answer the questions.

1. Name the time zones in the United States. (They are the same for Canada.)

2. When it is 2 p.m. in the Eastern zone, what time is it in the Mountain zone?

3. When it is 4 a.m. in the Pacific zone, what time is it in the Mountain zone?

4. When it is midnight in the Central zone,
a) what time is it in the Pacific zone? _____
b) what time is it in the Eastern zone? _____

THE INTERNATIONAL DATE LINE

Imagine that you are traveling westward. You set your watch back one hour for each meridian you pass. If you travel eastward, you set your watch forward the same amount.

If you travel completely around the world, you will change your watch by 24 hours. This means that you will be one day ahead or one day behind. It depends upon the direction you travel.

At which point of the globe would the date change? Actually, any point IF that is the starting and ending point of the journey. BUT "any point" would be confusing.

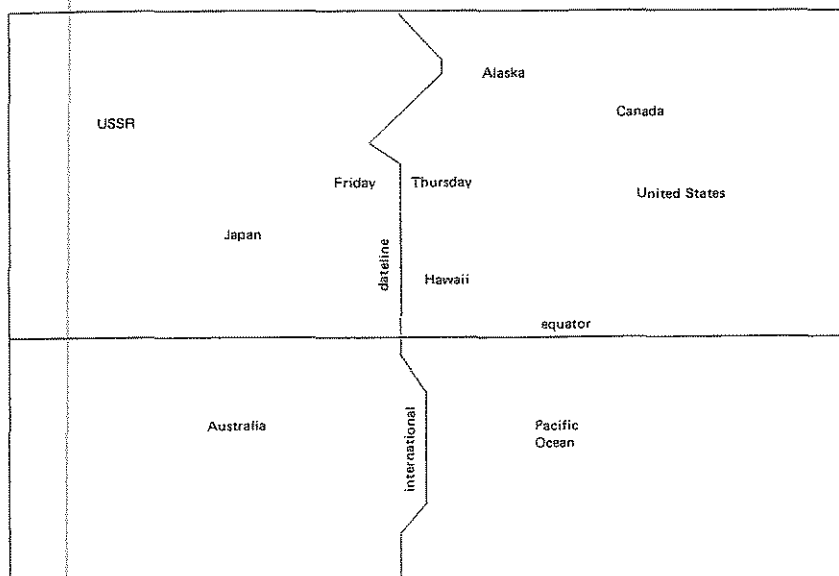


Figure E

Some standard place was needed. The standard place was set at the 180° meridian. The 180° meridian is called the international date line. Days change when you cross this line—and only this line.

When you cross the international date line from east to west you add one day. Sunday, for example, becomes Monday.

When you cross the international date line from west to east, you subtract one day. Sunday becomes Saturday.

Now answer these questions:

1. When it is Tuesday in the United States, what day is it in Japan?

2. When it is Wednesday in Australia, what day is it in Alaska? _____
3. When it is Friday in Hawaii what day is it in Canada? _____

CHOOSE Choose the correct word or term for each statement. Write your ONE choice in the space.

1. Time depends upon the earth's _____
revolution, rotation
2. The sun seems to move across the sky from _____
west to east, east to west
3. Places in the west see the sun _____ places in the east.
before, after
4. Time to the west is _____ than time to the east.
earlier, later
5. Time to the east is _____ than time to the west.
earlier, later
6. The earth is divided into _____ time zones.
12, 24, 60
7. Time zones run _____
vertically, horizontally
8. The starting time line is called the _____
prime meridian, international date line
9. The time difference between time zones is one _____
day, hour, year
10. For each time zone to the east, you _____ one hour.
add, subtract
11. For each time zone to the west, you _____ one hour.
add, subtract
12. The number of degrees between time zones is _____
90, 15, 180
13. Days change when you cross the _____
prime meridian, international date line
14. It is a day later when you cross the international date line from _____
west to east, east to west
15. It is a day earlier when you cross the international date line from _____
west to east, east to west

REACHING OUT

The meridians divide the earth into time zones. But they also tell us how far east or west a place is. Location east or west is measured in degrees of *longitude*.

There are also imaginary lines that run parallel to the equator. These are lines of *latitude*. They tell us how far north or south of the equator a place is in degrees of latitude.

Look at Figure F. It shows the lines of latitude and longitude. Find the dot that marks the location of 30° south latitude and 60° west longitude. This may be written as 30° S latitude; 60° W longitude.

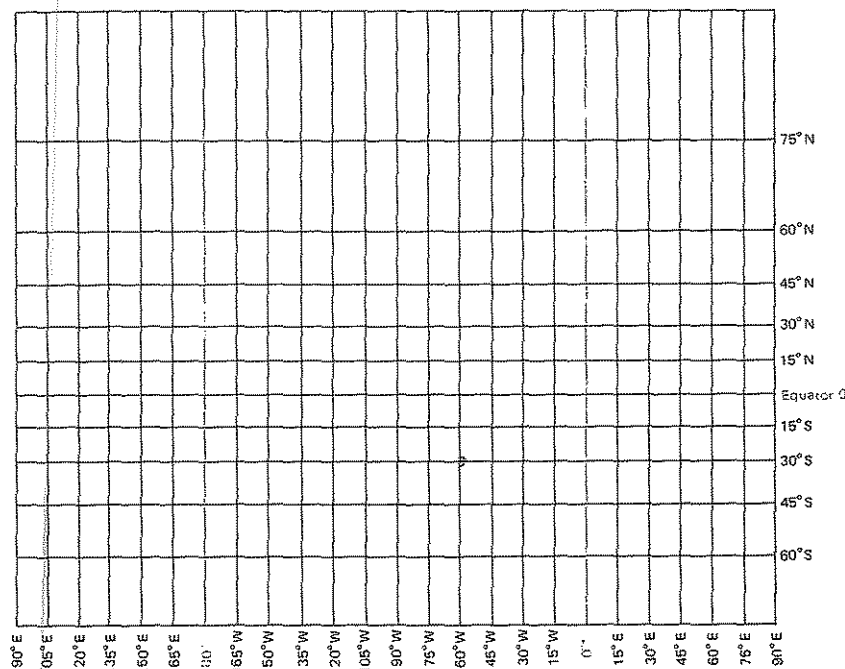


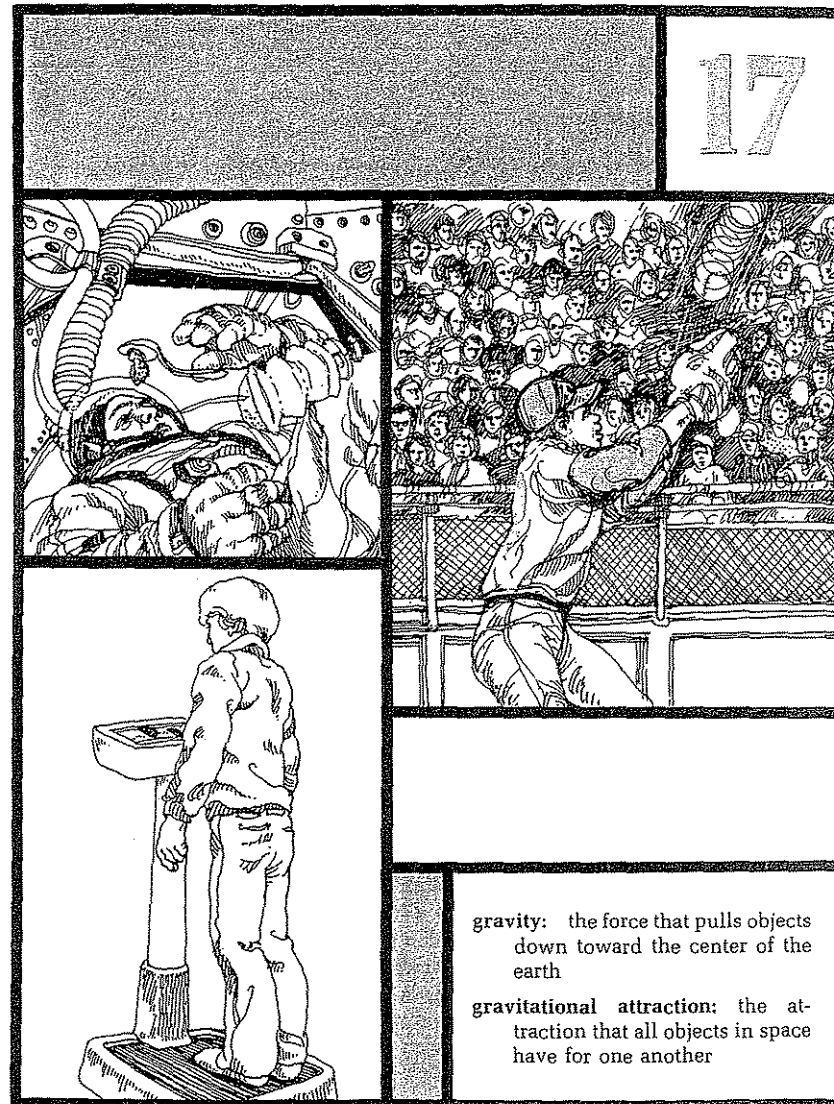
Figure F

Now find each of the following locations. Mark each with a dot and its number.

- | | |
|-------------------------------------|-------------------------------------|
| 1. 30° S latitude; 135° E longitude | 2. 60° N latitude; 105° W longitude |
| 3. 60° N latitude; 75° E longitude | 4. 15° N latitude; 105° E longitude |
| 5. 0° latitude; 15° W longitude | 6. 45° N latitude; 90° W longitude |

WHAT IS GRAVITY?

17



gravity: the force that pulls objects down toward the center of the earth

gravitational attraction: the attraction that all objects in space have for one another

AIM | What is gravity?

17

You throw a ball into the air. It moves upward for a very short time. Then it starts falling back to earth. Why does it fall back? Why doesn't it keep moving upward?

There is a force called gravity. Gravity is a *pulling* force. It is the force that attracts objects towards one another.

On earth, gravity pulls objects downward. It is the earth's gravity that pulls a ball down to earth. It is gravity that holds you to the ground. Without gravity, you (and everything else around you) would float away into space.

Every object has gravity, from the tiniest atom, to the largest star. How strong an object's gravity is depends upon two things:

1. How much matter an object has and
2. how far away the object is.

AMOUNT OF MATTER The amount of matter an object has gives that object its "built-in" gravity. Most large objects have more matter than smaller objects. Therefore, most large objects have stronger gravity than small objects.

DISTANCE The closer you are to an object, the more its gravity is felt. The farther you are from an object, the less its gravity is felt.

Every object in the universe pulls on every other object. This pulling is called *gravitational attraction* [grav i TAY shun ul uh TRAK shun]. Neighboring objects in space do not collide because their attractions are *balanced*. They are spaced in such a way that each one pulls on each other with an *equal* force. *Because of this*, they stay at a distance from one another.

Gravity is the force that holds the planets in their paths around the sun. Gravity is the force that keeps the moon in its orbit around the earth. In fact, gravity is the force that keeps the entire universe moving in an orderly way.

GRAVITY AND SIZE

Look at Figures A and B. Then answer the questions.

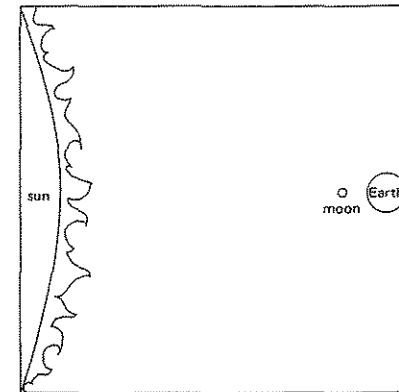


Figure A

1. Does every object shown in Figure A have gravity? _____
2. Is every object's gravity equally strong? _____
3. Usually, which has stronger gravity, small objects or large objects? _____

4. Usually, which has weaker gravity, small objects or large objects? _____

5. a) Which has stronger "built-in" gravity, the sun or the earth? _____
- b) Why? _____
6. a) Which has stronger "built-in" gravity, the earth or the moon? _____
- b) Why? _____

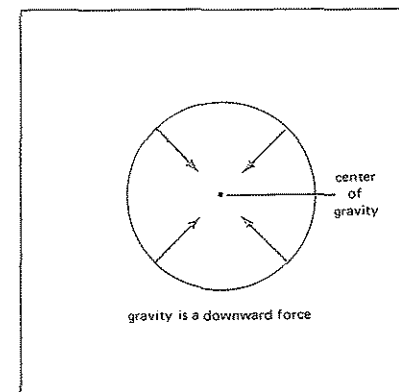


Figure B

7. Gravity seems to pull towards a single point in every object. What is this point called? _____
8. Gravity is a _____ force.
pulling, pushing
9. An object's gravity pulls things _____ the object.
toward, away from

GRAVITY AND DISTANCE

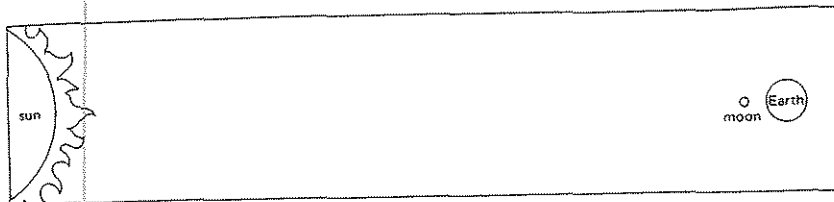


Figure C

Answer the questions below. Check with the reading and Figure C.

- The amount of matter an object has gives it its "built-in" gravity. But what else affects how much of this gravity is felt? _____
- Does distance change an object's "built-in" gravity? (Think carefully!) _____
- Which of the bodies in the Figure C has the strongest "built-in" gravity? _____ Why? _____
 - Which has the weakest? _____ Why? _____
- The sun has stronger gravity than the moon. Yet we feel the moon's gravity more.
 - Why do we feel the moon's gravity more than the sun's gravity? _____
 - Why do we feel the sun's gravity less than the moon's gravity? _____
- If the sun were closer, we would feel its gravity _____, more, less.
 - If the sun were farther away, we would feel its gravity _____, more, less.
- Why doesn't the earth shoot out into space? _____
- Gravity between the earth and the moon is balanced. How do we know this? _____

GRAVITY GIVES AN OBJECT ITS WEIGHT



Figure D

If you weigh 45 kg (100 lbs.), it means that the earth's gravity is pulling you downward with a force of 45 kg.

How much would you weigh on the moon—or the sun?

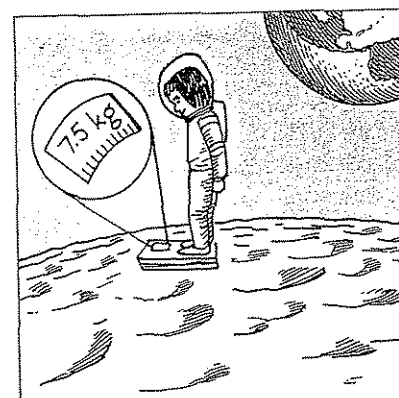


Figure E

On the moon, you would weigh just one sixth that weight. You would weigh just 7.5 kg (16.6 lbs.).

- Why would you weigh so little on the moon? (Use gravity in your answer.) _____

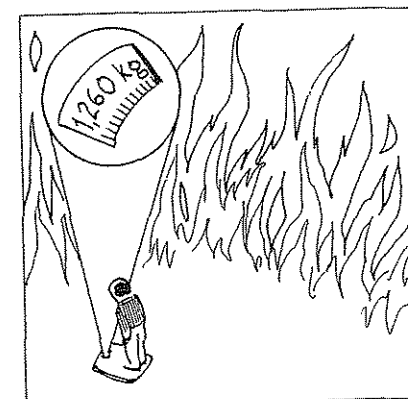


Figure F

On the sun, you would weigh 28 times your weight on earth. You would weigh 1,260 kg (2,800 lbs.).

- Why would you weigh so much on the sun? (Use gravity in your answer.) _____

COMPLETING SENTENCES Complete the sentences with the choices below.

matter
stronger
sun
weight

built-in
moon
gravity
more

less
downward
weaker
far away

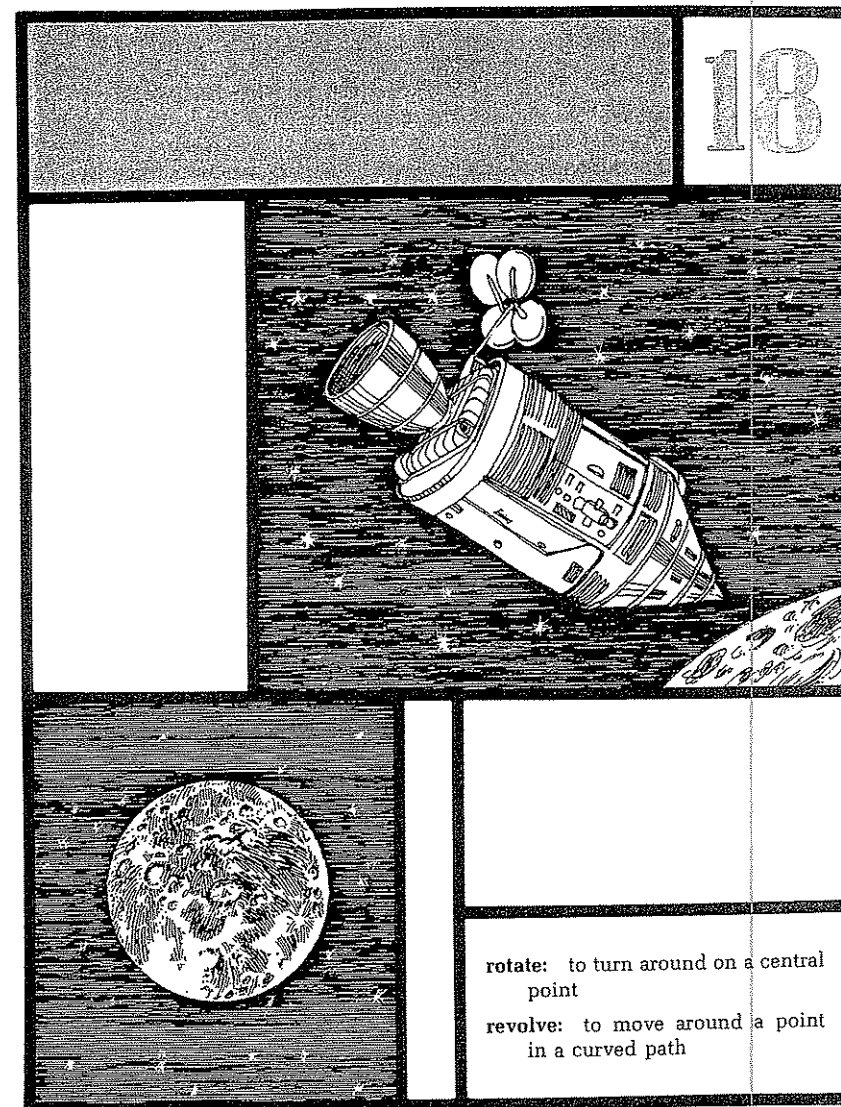
1. The force that pulls objects towards one another is called _____.
2. Gravity is a _____ force.
3. Gravity gives an object its _____.
4. Gravity depends upon two things: the amount of _____ an object has, and how _____ the object is.
5. The amount of matter an object has gives the object its "_____ " gravity.
6. Usually, more matter means _____ "built-in" gravity.
7. Usually, less matter means _____ "built-in" gravity.
8. When you move closer to an object, you feel its gravity _____.
9. When you move away from an object, you feel its gravity _____.
10. Gravity keeps the _____ moving around the earth. It also keeps the planets moving around the _____.

TRUE OR FALSE Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

1. _____ Gravity is an upward force.
2. _____ The moon and the sun have gravity.
3. _____ The moon pulls on the earth.
4. _____ The sun pulls on the earth.
5. _____ We feel the sun's gravity more than we feel the moon's gravity.

WHY CAN WE SEE ONLY ONE SIDE OF THE MOON?

18



rotate: to turn around on a central point
revolve: to move around a point in a curved path

AIM | Why can we see only one 18 | side of the moon?

On August 10, 1966, an Atlas Agena rocket blasted off from Kennedy Space Flight Center. It carried an unmanned satellite—Lunar Orbiter 1. Four days later, Orbiter 1 was circling the moon. This satellite sent back many pictures. Some showed the back half of the moon.

From the earth, we can see only one side of the moon. The other side of the moon always faces away from us.

Why does only one side of the moon face us? The explanation is really simple:

The moon rotates. That is, it turns around its own center just like a merry-go-round. But, while the moon is rotating, it is also revolving. It is moving around the earth.

- One moon rotation takes $27\frac{1}{4}$ days.
- One moon revolution takes the same time— $27\frac{1}{4}$ days.

The periods of rotation and revolution are the same. The moon turns around its center once for each time it moves around the earth.

Because of this, only one side of the moon faces us. The opposite side always is hidden from the earth.

The exercises on the following pages will help you understand how this happens.

UNDERSTANDING ROTATION

(Use yourself as a model.)

What you need to know:

- During one rotation, you face in every direction of a circle.
- At the end of one rotation, you face the same direction as when you started.

Imagine that you are making one complete rotation. The diagrams below show what you look like. A, B, C, and D are points around you.

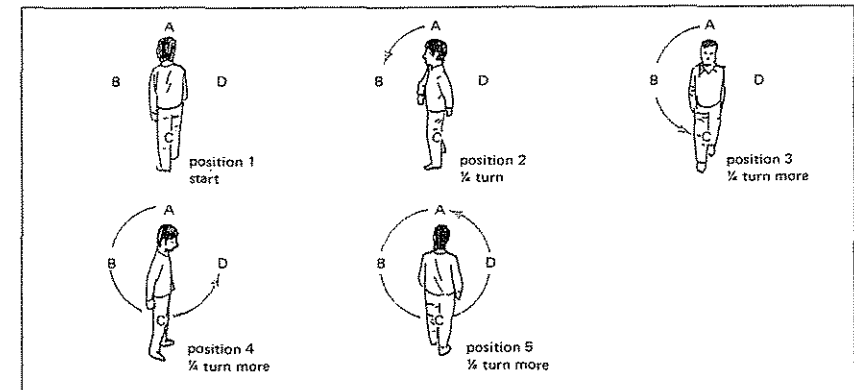


Figure A

1. a) List the points you expect to see as you turn. _____
 b) Will you see the places between these points? _____
2. At one quarter turn, which point do you see? _____
3. a) At two one-quarter turns, which point do you see? _____
 b) Two one-quarter turns equals which fraction of one turn? $\frac{1}{2}$
 c) Look at your starting position. At one half turn, the direction you face is _____
 the same, just opposite
4. a) At three one-quarter turns, which point do you see? _____
 b) Three one-quarter turns equals which fraction of one turn? $\frac{3}{4}$
5. When you make one more quarter turn, which point do you see again?

6. a) Four one-quarter turns of this kind of movement equals one

rotation, revolution

- b) How do you know you make one rotation? _____

7. a) Did you also revolve? _____

- b) How do you know? _____

UNDERSTANDING REVOLUTION

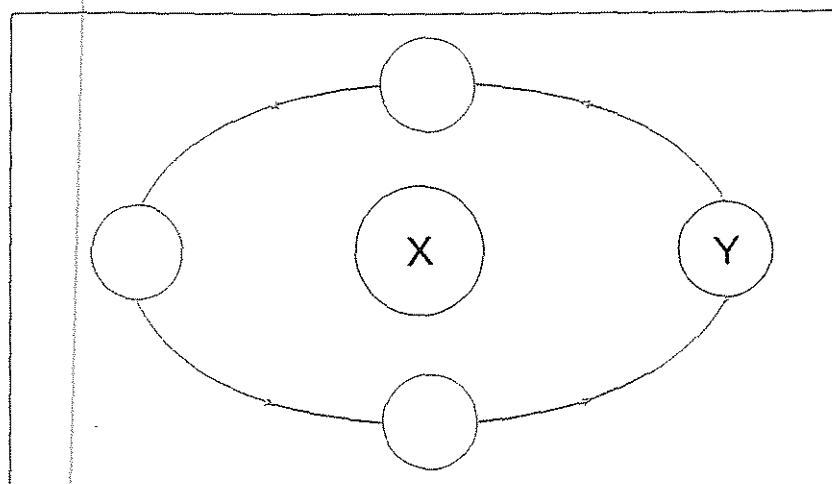


Figure B

Revolution simply means making a complete turn around another object.

1. In the diagram above _____ is revolving around _____.

X, Y

X, Y

Use your common sense to answer these questions:

2. When an object revolves can it also rotate? _____
3. Must it also rotate? _____

ROTATION AND REVOLUTION

The ballet dancer in Figure C is rotating. She is also revolving.

Study the diagram. Then answer the questions.

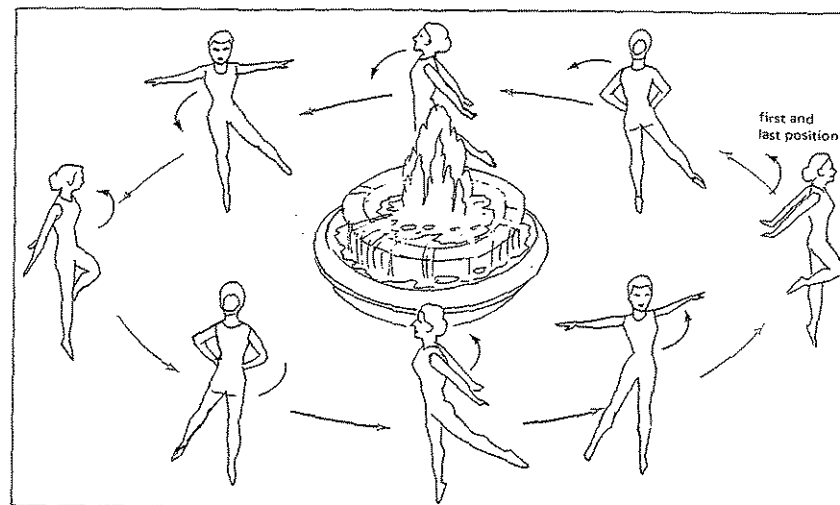


Figure C

1. How many revolutions has the dancer made? _____
2. How many rotations has the dancer made? (Count how many times she has returned to her starting position.) _____
3. During the single revolution, which side (or sides) of the dancer faced the fountain?

Her right side only. Her left side only. Her front only. Her back only. Every side

4. Which side or sides would face the fountain if the dancer rotated
- a) 3 times? _____
- b) 5 times? _____
- c) 10 times? _____ (Choose your answers from question 3.)
5. Conclusion: When an object rotates two or more times as it revolves around an object _____

only one side faces the object. all sides face the object

NOW LET'S LOOK AT A SPECIAL CASE

(At the same time you will get back into the act!)

Imagine that you are walking (revolving) around a chair. The diagram below shows what you look like.

Study the diagram. Then answer the questions.

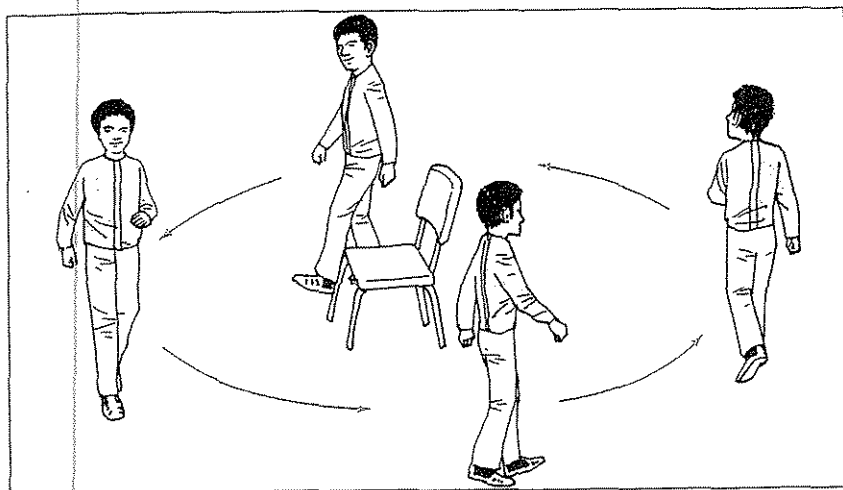


Figure D

- How many revolutions have you made? _____
- At half way through the revolution, you were facing _____ the opposite, the same direction as when you started.
 - At one revolution, you were facing _____ the opposite, the same direction as when you started.
- What were you doing while you were revolving? _____
 - How many times? _____
- As you were revolving and rotating, how many sides of your body faced the chair?
 one, two, three, all _____
- Conclusion: When an object rotates *once for each time it revolves* around an object, _____
 only one side faces the object, all sides face the object

NOW LET'S MAKE SOME CHANGES

- ▣ Let the earth take the place of the chair, and
- ▣ the moon take your place. (Sorry about that!)

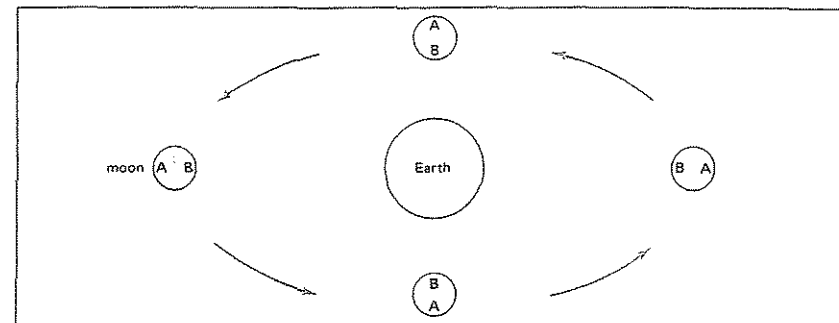
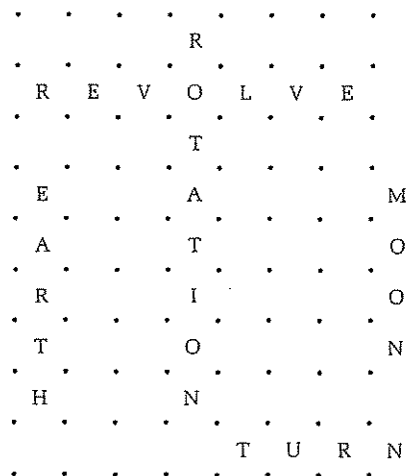


Figure E

- How many times does the moon rotate in $27\frac{1}{2}$ days? _____
- How many times does the moon revolve in $27\frac{1}{2}$ days? _____
- How many sides of the moon can we see from earth? _____
 - Why? _____

CONNECTING DOTS

Each player draws a line. If the line completes a box, then the player goes again. Put your initials in the boxes you complete.



Scoring:
 empty box counts 1 point
 box with a letter counts 2 points
 add 10 points for each complete word

SCORE

Name _____ Name _____

REACHING OUT

How can you revolve around a chair without rotating? (Try it!) _____

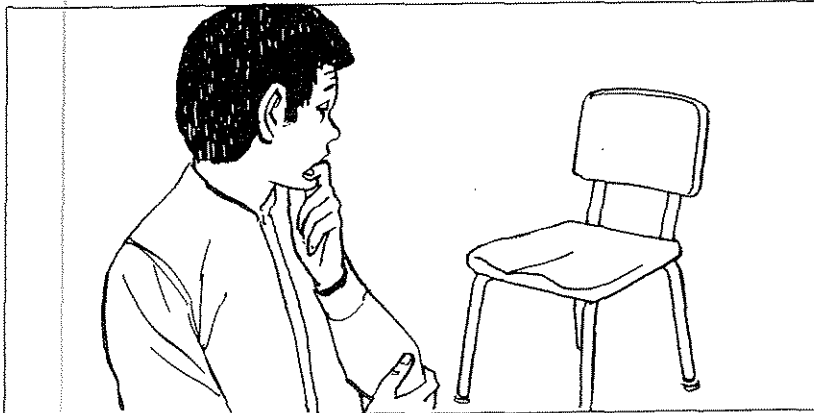
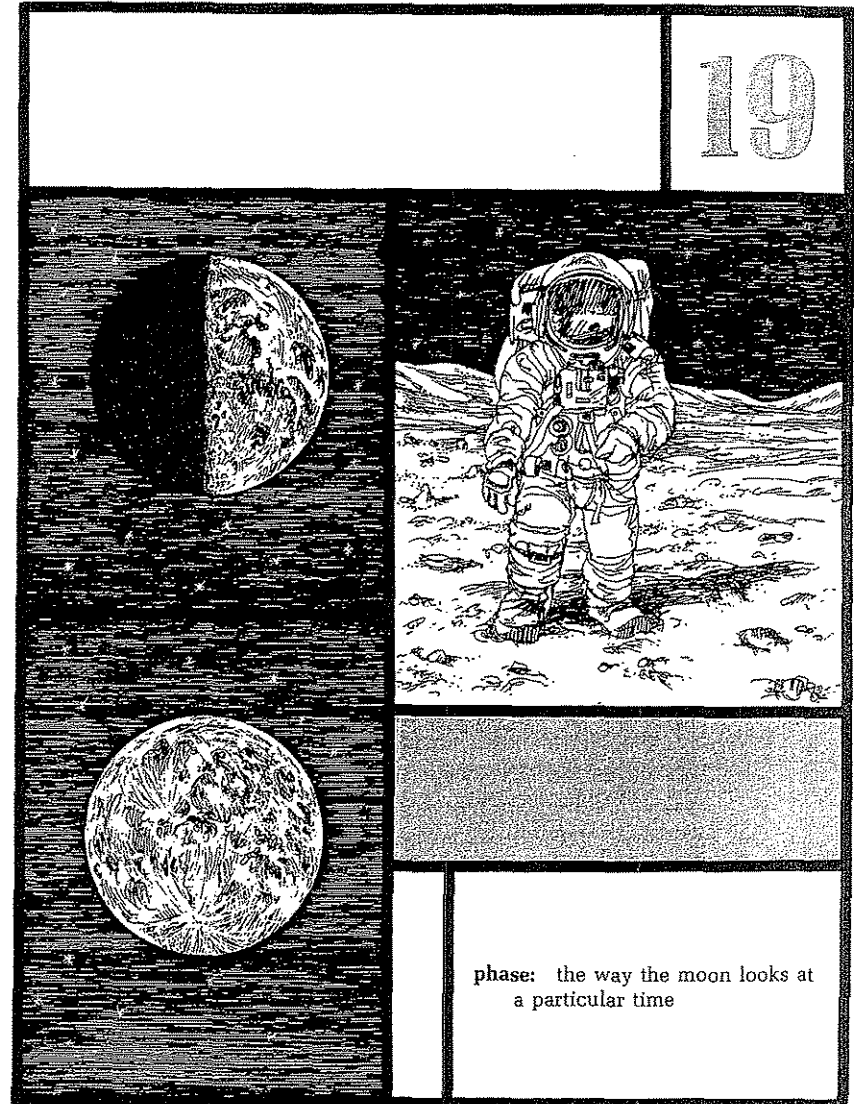


Figure F

WHY DOES THE MOON SEEM TO CHANGE SHAPE?

19



phase: the way the moon looks at a particular time

AIM | Why does the moon seem to 19 | change shape?

The date: July 20, 1969. American astronaut Neil Armstrong became the first person to set foot on the moon. Since then other Americans walked on the moon. They did important experiments there. They also brought back many rock samples.

We know more about the moon now than ever before.

The moon is our closest neighbor in space. It is about 400,000 kilometers (250,000 miles) away. As space distance goes, that's "almost touching."

The moon does not give off its own light like the sun does. It shines by reflected light. The sun shines on the moon. The moon then reflects the light from the sun.

You can see the moon shining brightly on almost any clear night. But from night to night, the moon seems to change its shape. The different shapes the moon seems to have are called phases. Figure A shows the phases.

If you look at the moon every night, you will notice that the phases always follow one another in the same order. First the moon may look like a large white disk. Then it seems to shrink and disappear only to start "growing" again.

Why does the moon seem to change shape? The moon revolves, or orbits, around the earth. One orbit takes about 27½ days. During this time, about half of the moon is always lit up. But, most of the time we cannot see all this light.

How much moonlight we see depends upon where the moon is in its orbit. At *full moon*, we see *all* of the light. At *new moon*, we see none of the light. At all other phases, we see part of the light.

UNDERSTANDING THE MOON'S PHASES

Figure A shows the moon in orbit. Study it and then answer the questions or fill in the blanks below.

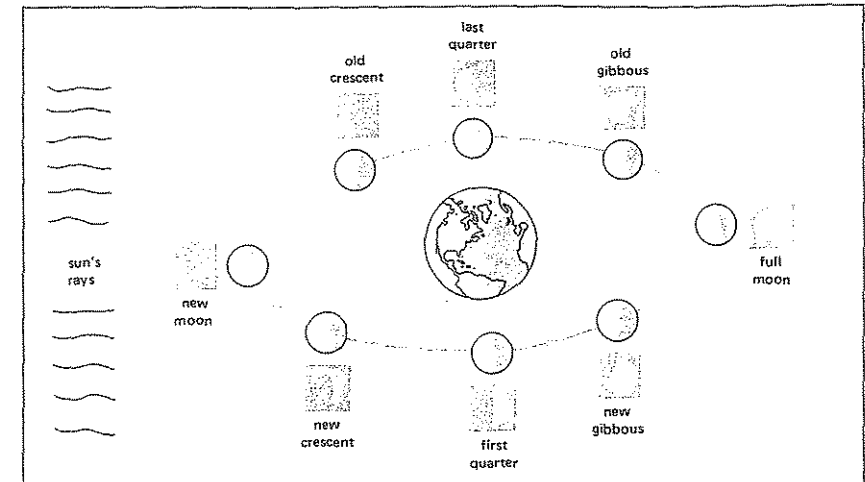


Figure A

The side of the moon facing the sun is always lit up. But we do not see it this way every night. The boxes show how the moon looks to us here on earth. Notice how its shape seems to change during the orbit.

1. What do we call the different shapes the moon seems to have? _____
2. Where does the moon get its light? _____
3. a) How much of the moon is always bright? _____
b) Can we see all this light every night? _____
4. At which phase can we see all of the lighted half of the moon? _____
5. At which phase can we see none of the lighted half of the moon? _____
6. At which phases can we see one half of the lighted half of the moon? _____
7. At which phases can we see less than one half of the lighted part of the moon? _____
8. At which phases can we see more than one half, (but not all) of the lighted half of the moon. _____

MORE ABOUT THE MOON

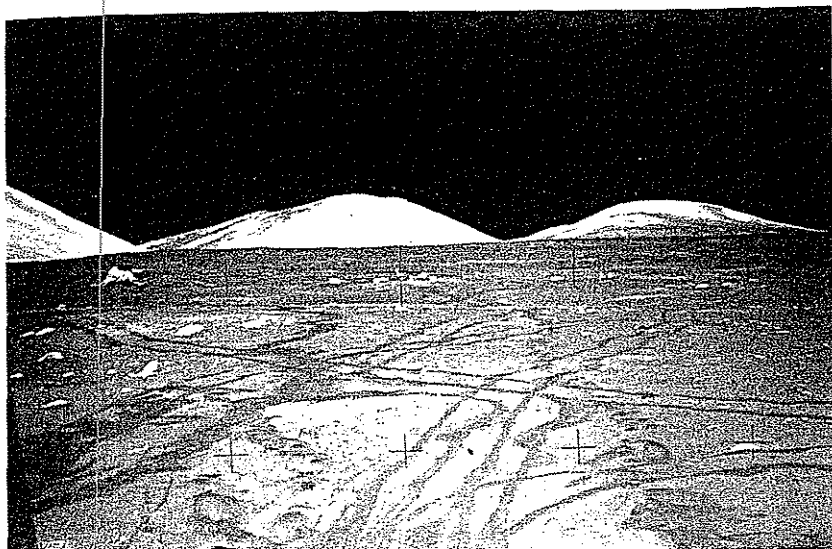


Figure B A photo of the moon taken by Apollo 17 astronauts

We now know for certain. The moon has no air and no water.

1. Do you think there is life on the moon? _____
2. Why? _____

MATCHING

Match the two lists. Write the correct letter on the line next to each number.

- | | |
|--|---|
| 1. _____ phases | a) moon's different appearances |
| 2. _____ moon's orbit around the earth | b) moon not visible |
| 3. _____ by reflected light | c) has pointed ends |
| 4. _____ crescent moon | d) causes moon to change its appearance |
| 5. _____ new moon | e) the way the moon shines |

TRUE OR FALSE Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

1. _____ The earth orbits around the moon.
2. _____ The moon really changes its shape.
3. _____ The moon gives off its own light.
4. _____ The moon reflects light from the sun.
5. _____ About one half of the moon is always bright.
6. _____ We can always see half of the moon.
7. _____ We can see half of the moon at new moon.
8. _____ This  , is a full moon.
9. _____ This  , is a gibbous moon.
10. _____ This  , is a crescent moon.

NAMING THE PHASES OF THE MOON

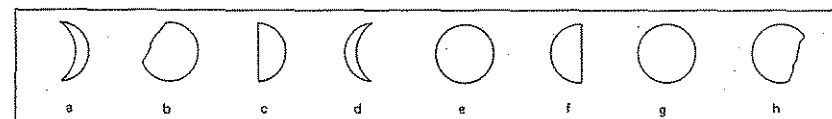
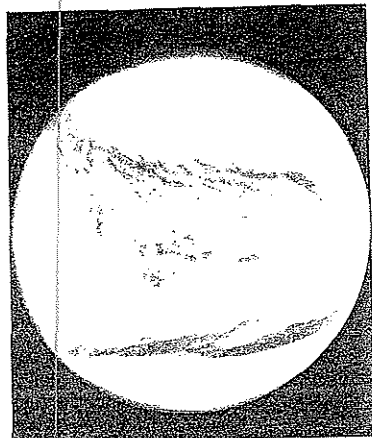


Figure C

Seven moon phases are shown in Figure C. Can you name them? Write your answers in the chart below. Answer by letter.

	Phase	Letter (or letters)
1.	Gibbous moons	
2.	New moon	
3.	Crescent moons	
4.	Full moon	
5.	Quarter moons	

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A

MESSAGE FROM VENUS

Venus is the closest planet to Earth. The two planets are about the same size and density. But in almost all other ways they are very different.

Venus is wrapped in a dense atmosphere of carbon dioxide. During Earth's early years, it too, had much carbon dioxide in its atmosphere. But most of the carbon dioxide combined with water and formed the carbonate rocks.

The clouds of Venus are made up of sulfuric acid—not of water. Its surface

temperature reaches 482°C (900°F). This is hot enough to melt lead. The air pressure at the surface of Venus is 90 times greater than that of Earth.

Clearly, life cannot exist on Venus. But Venus interests scientists because it has an important message for us. It is a message about Earth's possible future. This message warns us that the carbon dioxide in our atmosphere could also make Earth's temperature rise enough to kill all life. The burning of wood and fossil fuels releases more and more carbon dioxide into the air. And carbon dioxide holds back heat. Let's see how.

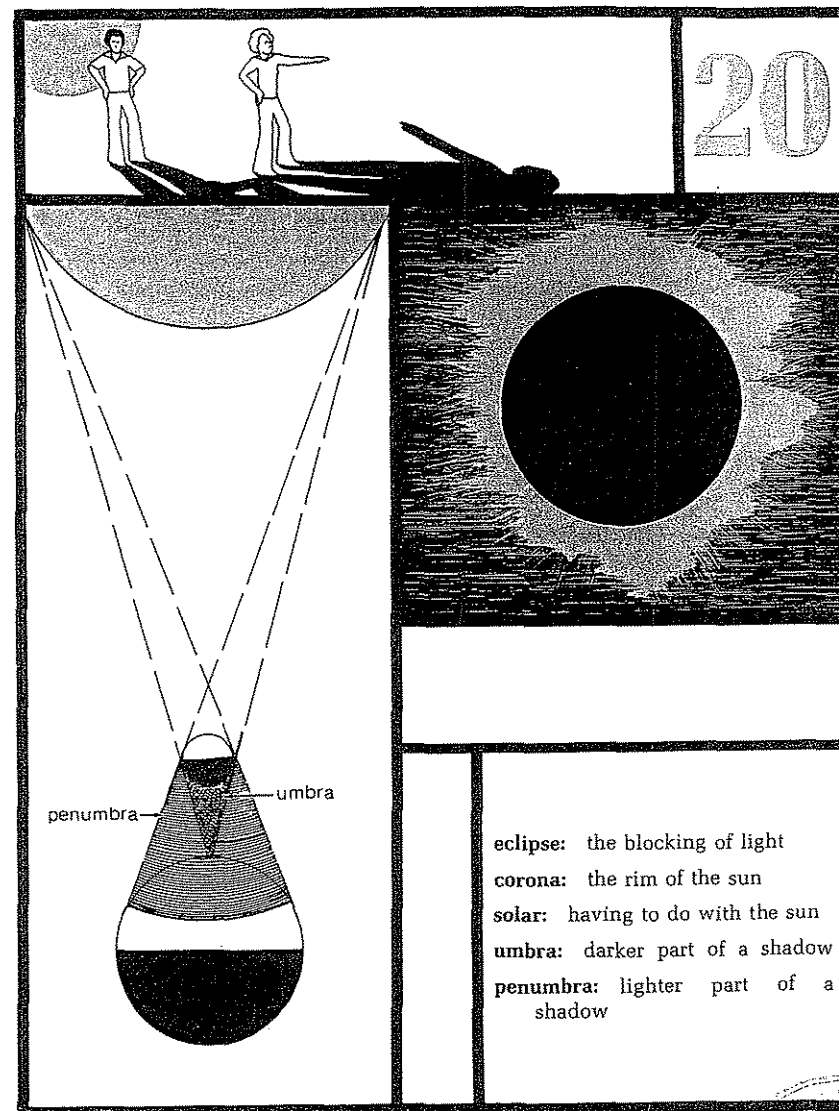
The sun's radiation heats our planet—as it does Venus. Much of this heat bounces back into space. An atmosphere high in carbon dioxide prevents much of the heat from leaving the atmosphere. In this way, the temperature of Earth's atmosphere could rise. Polar ice caps would melt. The ocean level would rise, and coastal cities would be covered with water.

Venus' message is clear. Earth can become like Venus. NASA's planetary scientist James Pollack says, "It's really a possibility." What can we do about it? The obvious answer is to stop polluting the atmosphere with carbon dioxide. To do this, we must continue research in solar, wind, water, and nuclear energies.

The effects of carbon dioxide in the atmosphere is understood. However, we have not kept temperature records long enough to know whether the atmosphere has really become warmer in the last 100 or 200 years. Also, some scientists believe that ocean water absorbs carbon dioxide. And we know that plant life uses carbon dioxide and produces oxygen and sugars. So here is another warning. Preserve the forests.

WHAT IS A SOLAR ECLIPSE?

20



eclipse: the blocking of light

corona: the rim of the sun

solar: having to do with the sun

umbra: darker part of a shadow

penumbra: lighter part of a shadow

AIM | What is a solar eclipse? 20

Everyone has seen shadows. You have seen shadows of trees, buildings, and fences. How often have you noticed your own shadow following you? You can see a shadow right now! Just hold your hand close to this page. What do you see on the page?

What is a shadow? A shadow is an area of darkness. It forms when an object gets in the way or blocks light.

Every object that blocks light forms a shadow. The earth and moon are no exceptions. The earth and moon block the sun's light. They cast huge cone-shaped shadows deep into space.

The earth and the moon are always moving. So are their shadows. Sometimes these shadows block out, or eclipse, parts of the sky.

There are two kinds of eclipses: the solar eclipse and the lunar eclipse. A SOLAR ECLIPSE TAKES PLACE WHEN THE MOON PASSES INTO A STRAIGHT LINE BETWEEN THE SUN AND THE EARTH.

When the moon is in this position, its shadow moves onto a small area of the earth. The shadow blocks out (eclipses) the sun. It becomes dark. And for a short time, day changes to night. Only a halo of light from the sun's rim can be seen. This halo is called the corona. It can be seen only during an eclipse.

UNDERSTANDING A SOLAR ECLIPSE

Figures A through F show what happens during a solar eclipse. Study them and answer the questions.

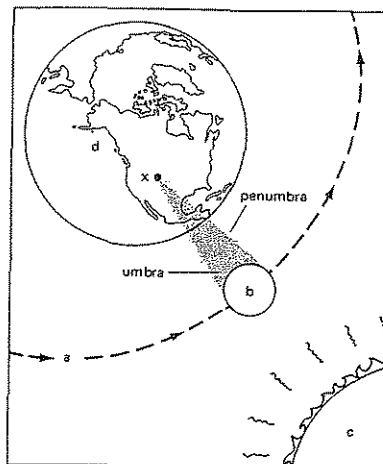


Figure A

The sun, moon, and the earth line up in a straight line during a solar eclipse.

Identify the following by letter:

1. sun _____
2. earth _____
3. moon _____
4. moon's orbit _____

The moon's shadow has a darker, center part and a lighter outer part.

5. What do we call the darker, center part? _____
6. What do we call the lighter, outer part? _____

If you were living in the umbra you would see a total solar eclipse.

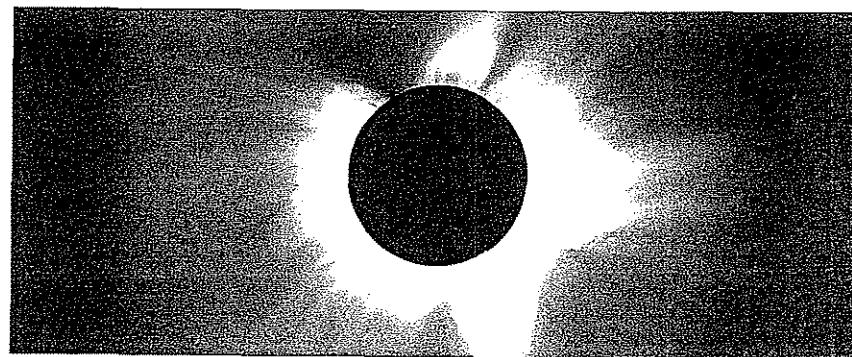


Figure B A total solar eclipse

7. Look back to Figure A. If you were at point x on the earth you would see a _____ eclipse.

Total solar eclipses are rare. Most of the time the umbra of the moon's shadow misses the earth altogether. Then only a partial eclipse may be seen.

If you were living in the penumbra you would see a partial solar eclipse.

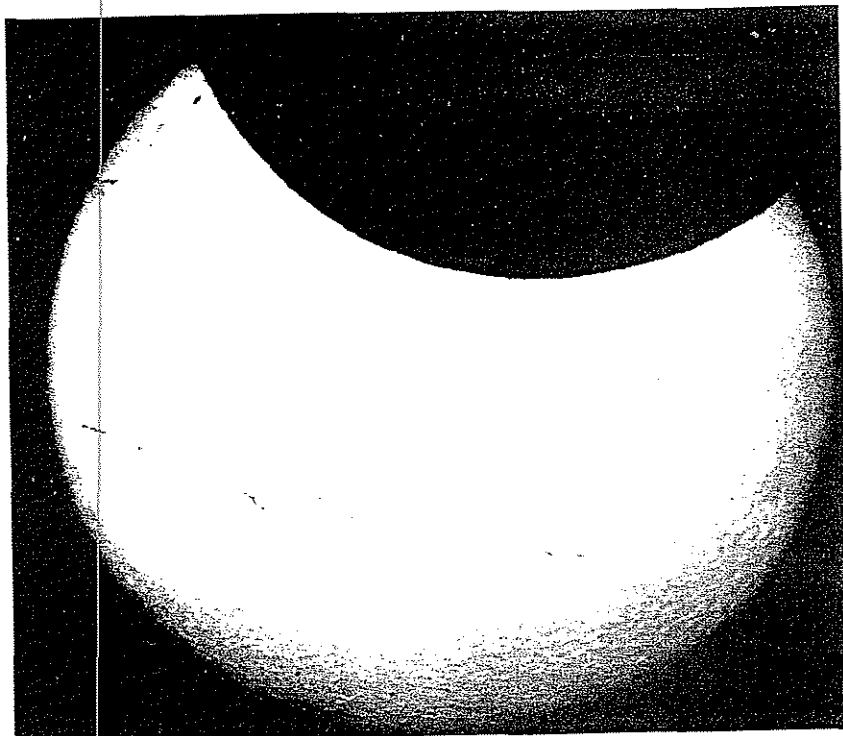


Figure C A partial solar eclipse

An eclipse seems to move across parts of the earth. This is because the earth and moon are moving.

The sun, moon, and the earth are not lined up as they are in a total eclipse. This is a partial eclipse. Where the umbra touches the earth (in the North Atlantic Ocean) is a total eclipse.

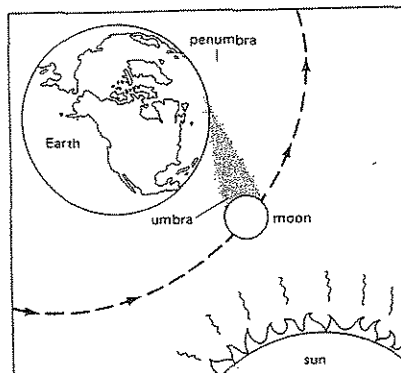


Figure D

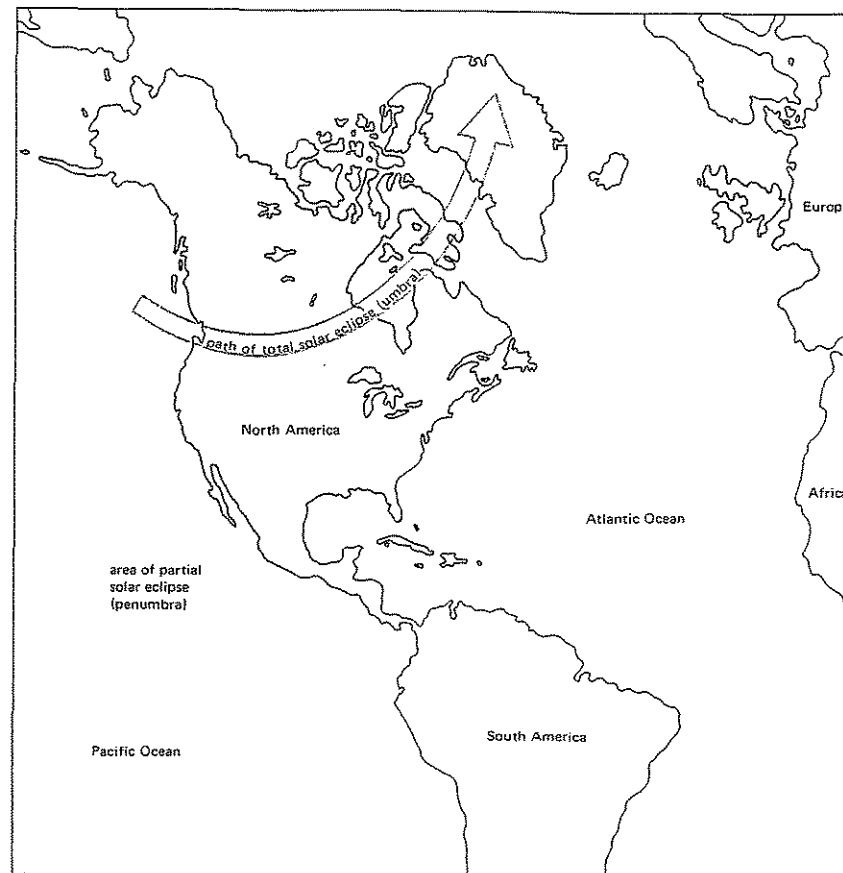


Figure E

This is the path of the total solar eclipse of February 26, 1979. The next such eclipse that can be seen from North America will not be until the year 2017.

A solar eclipse does not last long. If you stayed in one place the eclipse would last no more than a few minutes.

8. _____ solar eclipses can be seen more often than _____
Partial, Total partial, total
solar eclipses.
9. An eclipse seems to move because the earth and _____ move.
sun, moon
10. If you were in the path of the eclipse in Figure E, you would see an eclipse for a few _____
minutes, hours, days

Figure F shows what an eclipse looks like using time lapse photography.

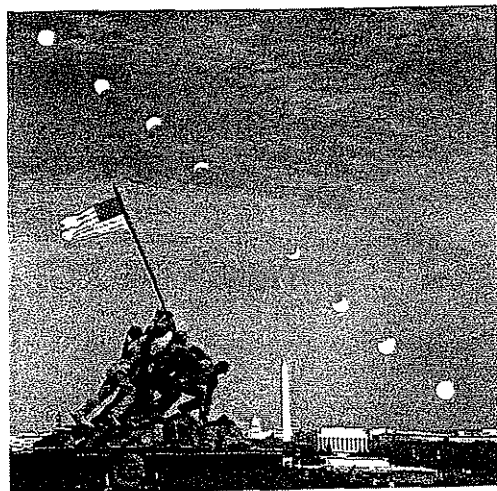


Figure F

NOW MAKE YOUR OWN SOLAR ECLIPSES

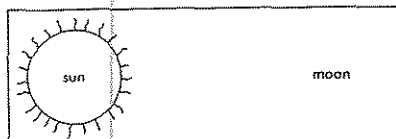


Figure G

What To Do

1. Get a piece of paper. Cut out a "moon" the same size as in Figure G.
2. Place the moon to the right of the sun in Figure G without letting them touch.
3. Slowly move the moon to the left over the sun. Make a partial eclipse.
4. Then make a total eclipse.

Check against the photos of a real eclipse. Do yours look the same?

The moon is really much smaller than the sun. But to us, the moon and sun look about the same size. Why?

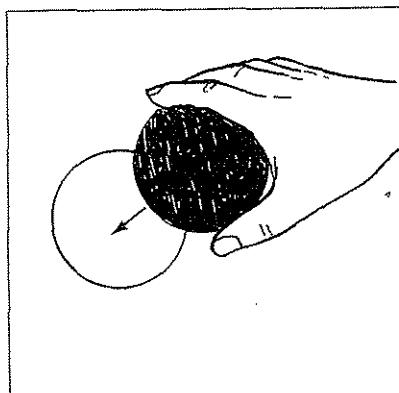


Figure H

COMPLETING SENTENCES Complete the sentences with the choices below. Two of these may be used twice.

solar eclipse
earth
partial
long cone-shaped shadows

sun
an eclipse
moves
blocks

total
darkness
moon
corona

1. A shadow is an area of _____.
2. A shadow forms when an object _____ light.
3. The _____ and _____ block the sun's light. They cast _____.
4. Sometimes the shadow of a heavenly body blocks out another heavenly body. This is called _____.
5. The blocking out of the sun by the moon's shadow is called a _____.
6. A solar eclipse occurs when the _____ is between the _____ and the _____.
7. When the moon blocks out all of the sun, we have a _____ eclipse.
8. When the moon blocks out a part of the sun, we have a _____ eclipse.
9. During a total eclipse, we can see only the sun's "halo." This is called the _____.
10. A solar eclipse _____ across part of the earth's surface.

MATCHING Match the two lists. Write the correct letter on the line next to each letter.

- | | |
|-------------------------------|-----------------------------|
| 1. _____ umbra | a) sun's halo |
| 2. _____ penumbra | b) darker part of a shadow |
| 3. _____ solar eclipse | c) usually not in a line |
| 4. _____ corona | d) sun blocked out |
| 5. _____ sun, earth, and moon | e) lighter part of a shadow |

TRUE OR FALSE Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

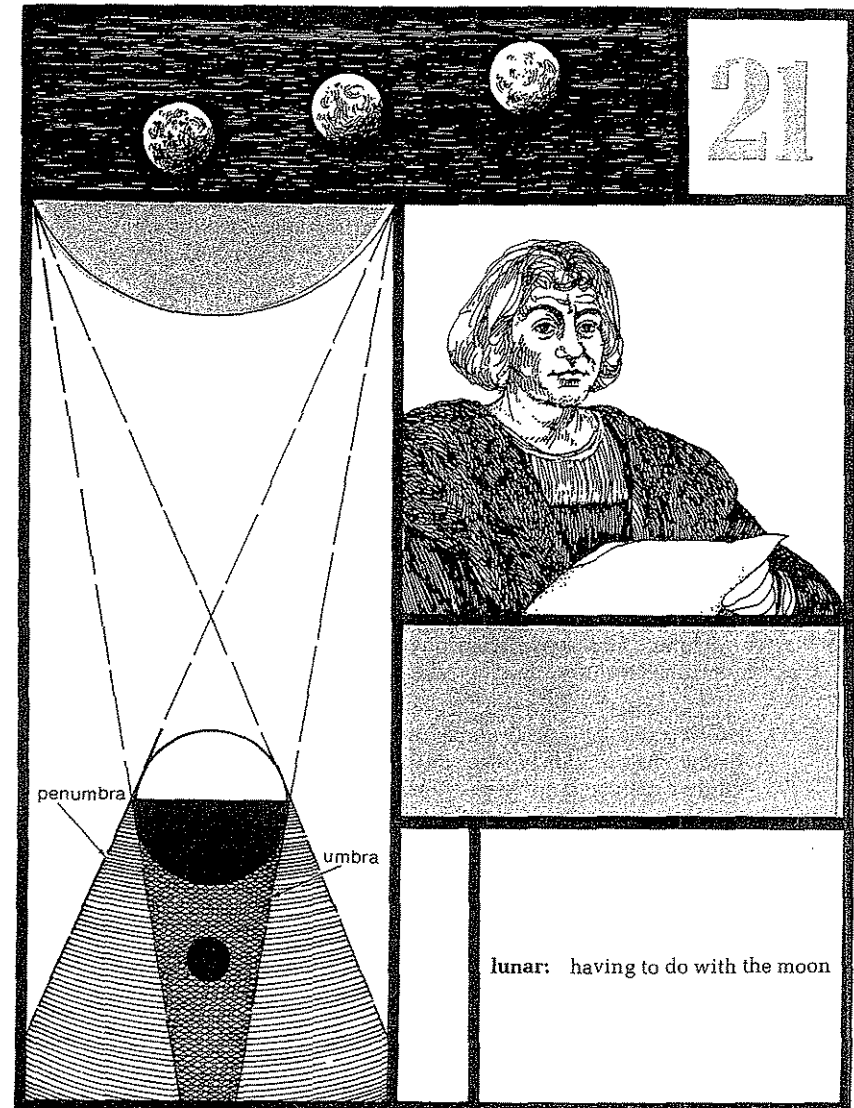
1. _____ A solid object can cast a shadow.
2. _____ The earth and moon cast shadows.
3. _____ Light is needed for a shadow to form.
4. _____ During a solar eclipse, we cannot see the moon.
5. _____ During a solar eclipse, earth is between the sun and the moon.
6. _____ A solar eclipse can be seen from any part of the earth that is having daylight at the time of the eclipse.
7. _____ A solar eclipse moves.
8. _____ A solar eclipse lasts a long time.
9. _____ There are more partial solar eclipses than total solar eclipses.
10. _____ You can always see the sun's corona.

REACHING OUT

A solar eclipse can take place only during one moon phase.

Which phase is it? _____

WHAT IS A LUNAR ECLIPSE?



AIM | What is a lunar eclipse?

21

As you know, the moon does not give off its own light. The moon gets its light from the sun. The light then reflects onto the earth.

The moon revolves around the earth. Most of the time the moon does not move into the earth's shadow. But sometimes it does. When the moon moves into the earth's shadow, we have a lunar eclipse.

During a lunar eclipse, hardly any sunlight reaches the moon. The moon becomes very dim.

You may ask, "How does the moon receive any sunlight when it is hidden in the earth's shadow?" The answer is that the earth's air "bends" some of the sun's light onto the moon. So, even when the moon is eclipsed, it is not completely blacked out. It just looks *dull red*.

A lunar eclipse lasts much longer than a solar eclipse. This is because the earth's shadow is very wide where the moon passes. The moon takes a long time to pass through.

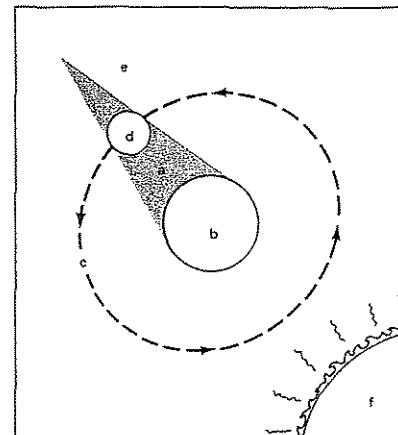
From start to finish, a lunar eclipse lasts from three to four hours and sometimes longer. This gives astronomers a long time to study the moon during an eclipse.

A lunar eclipse can be seen from more areas of the earth than a solar eclipse. The shadow of a solar eclipse is only a narrow strip. It can be seen only on a small part of the earth. A lunar eclipse is different. During a lunar eclipse, the entire moon is in shadow. It can be seen from any part of the earth that is having night at the time of the eclipse.

There are many more lunar eclipses than solar eclipses.

UNDERSTANDING A LUNAR ECLIPSE

Figure A shows a total lunar eclipse. Study it. Then fill in the blanks.



Identify the following by letter:

1. sun _____
2. earth _____
3. moon _____
4. moon's orbit _____
5. earth's umbra _____
6. earth's penumbra _____

Figure A

The sun, earth, and moon line up in a straight line in a lunar eclipse.

There are two kinds of lunar eclipses: *total* and *partial*.

▣ The moon looks like this when it is not eclipsed:



▣ A total lunar eclipse looks like this:



▣ A partial lunar eclipse may look like this,



or like this,



or even like this:



7. The moon is in *total* eclipse when it is in the earth's _____
umbra, penumbra
8. The moon is in *partial* eclipse when it is in the earth's _____
umbra, penumbra
9. When the moon is partly in the earth's umbra or penumbra, the eclipse is

total, partial

THE MOON'S POSITION DURING AN ECLIPSE

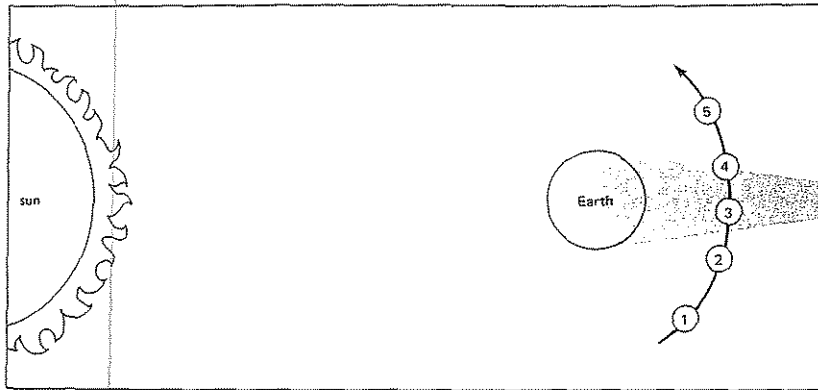
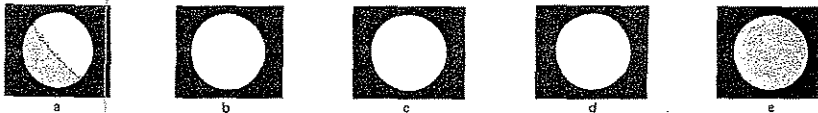


Figure B

Figure B shows the moon in 5 different positions. What does it look like in each position? Match the positions with the "moons" below.



Answer by letter.

1. In position 1, the moon looks like _____.
2. In position 2, the moon looks like _____.
3. In position 3, the moon looks like _____.
4. In position 4, the moon looks like _____.
5. In position 5, the moon looks like _____.

Now answer by number.

6. a) At which position is the moon not eclipsed at all? _____
b) Why is it not eclipsed? _____
7. At which position is the moon in total eclipse? _____
8. a) At which positions is the moon in partial eclipse? _____
b) Which one is partially eclipsed the most? _____

MOON SUPERSTITIONS

Many superstitions have to do with the moon.



Figure C

The word *lunatic* means a crazy person. It comes from *luna*, the old Latin word for moon.

Some people think that the full moon makes people behave strangely.

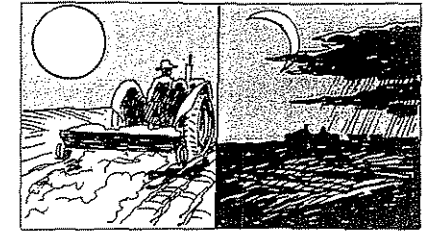


Figure D

Some farmers believed that certain crops should be planted when the moon is full and other crops when dark.

To some, a sharp, crescent moon with one "horn" lower than the other meant rain.

AN ECLIPSE SAVES COLUMBUS



Figure E

In February of 1504, Columbus and his men were forced to land on the island of Jamaica. The Indians there were very unfriendly. Columbus' men had run out of food. The Indians refused to bring them any.

Columbus was a good astronomer. He knew that within a few days there would be a lunar eclipse. On the day of the eclipse, Columbus warned the Indians that he would make the moon dark if they refused to bring food.

Then the moon started to eclipse. The Indians became very frightened. They promised Columbus food if he would make the moon shine again.

In a few hours, the eclipse was over. Columbus' knowledge of astronomy had helped save the lives of his men.

COMPLETING SENTENCES Complete the sentences with the choices below. One of these may be used twice.

moon
earth's air
predict
reflects

dull red
does not
longer
sun

earth
very wide
disappear
night

1. The moon _____ make its own light. The moon _____ the sun's light.
2. During a lunar eclipse, the moon passes through the shadow of the _____.
3. During a lunar eclipse, the _____ is between the _____ and the _____.
4. During a total lunar eclipse, the moon does not completely _____.
5. A "totally" eclipsed moon is not completely blacked out because the _____ bends some light onto it.
6. An eclipsed moon looks _____.
7. The earth's shadow is _____ where the moon passes.
8. A lunar eclipse lasts _____ than a solar eclipse.
9. When a lunar eclipse is taking place, it can be seen from any part of the earth that is having _____.
10. Scientists can _____ eclipses.

REACHING OUT

A lunar eclipse can take place only during one moon phase. Which phase is it?

WHAT CAUSES TIDES?

22

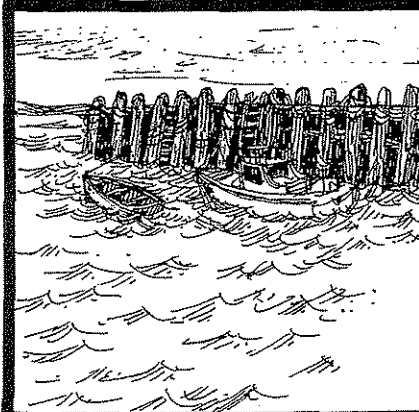
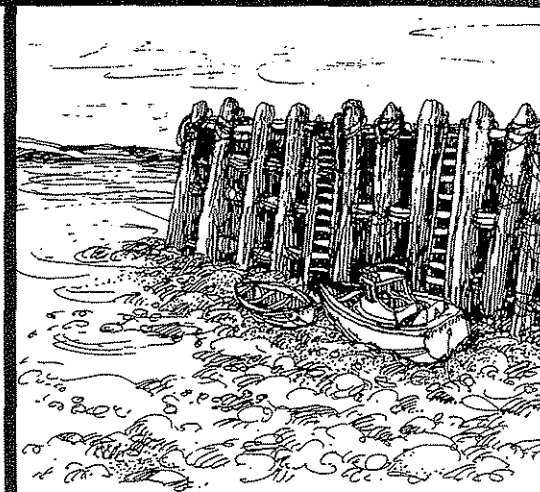
THE TIDES TOMORROW

PHILADELPHIA

High	Low
11:31 AM	6:07 AM
11:53 PM	6:36 PM

CAPE MAY HARBOR

High	Low
5:34 AM	11:37 AM
5:55 PM	11:49 PM



tide: the regular changing of the level of ocean water

AIM What causes tides?

22

Have you ever spent a day at the shore? If you have, then you know that ocean water does not stay at one level. At certain times of the day the water is higher than at other times. The water level rises and falls at regular time periods. We call this regular rise and fall of ocean water tides.

There are high tides and low tides. Look at Figure A on the facing page. It shows a coastline at low tide. Figure B shows the same coastline at high tide—just a few hours later. Notice the difference in the water level.

Tides do not change suddenly. High tide moves in slowly. Then, after the water reaches its highest point, it moves out slowly. A low tide always follows a high tide.

Most seashores have four tides every day—two high tides and two low tides. A change of tide takes about 6 hours and 12 minutes.

What causes tides?

Tides are caused by the pull of gravity by both the moon and the sun. The moon is more important because it is closer to the earth. The moon pulls on the earth with greater force than the sun.

The moon pulls upon the earth's land and water. The pull has hardly any effect upon the land. Rock does not move easily. But, water is different. Water moves very easily. It flows. The pull bulges the water on the part of the earth that is facing the moon. This part of the earth has high tide. There is also high tide on the opposite side of the earth—the side facing away from the moon. This is caused by the earth's rotation. The spin pushes the water outward.

Areas that supplied the water for high tide areas have low tides.

The earth is always rotating. As it turns, different parts face the moon. This causes the tides to keep changing. Tides follow the earth's rotation.

HIGH AND LOW TIDES

Look at Figures A and B. Answer the questions.

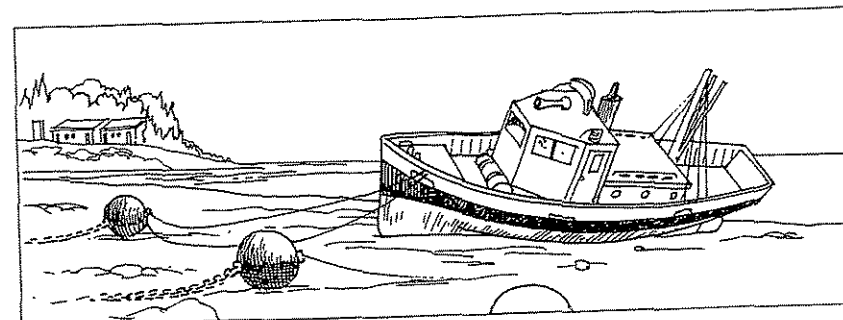


Figure A Low tide

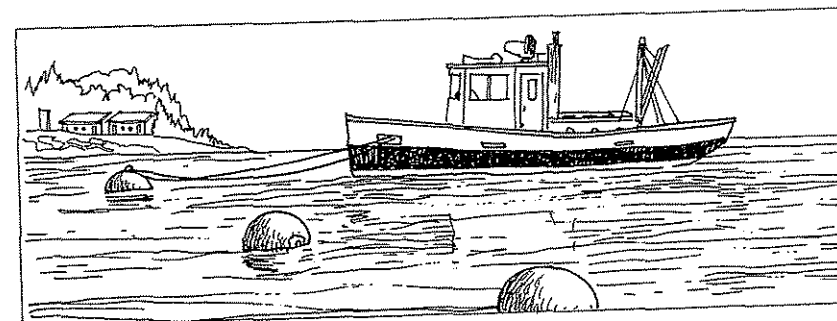


Figure B High tide

1. Why is the boat on land in Figure A? _____

Look at Figure B.

2. About how long did the water take to reach this point? _____
3. Which figure shows low tide? _____ A, B
4. There are no piers here.
 - a) If you were a fisherman, at which tide would you unload your catch? _____
 - b) At which tide would you go to sea again? _____
 - c) How many times a day could you go to sea? _____
 - d) How many times a day could you unload your catch? _____



Figure C

Fish usually come in on the incoming tide. Regular fishing is best then.

But, shell-fishing is best at low tide.

UNDERSTANDING THE VIDEO

Study figures D through G. Then answer the questions.

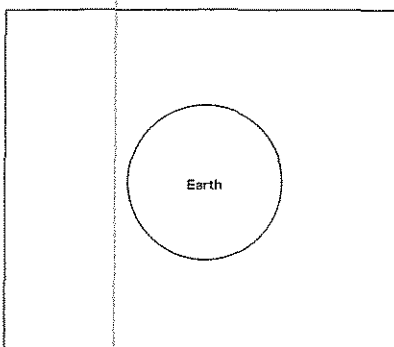


Figure D

If the moon and the sun did not pull on the earth, there would be no tides.

The ocean level would be the same everywhere.

But, the moon and the sun *do* pull on the earth.

1. a) Which one is more important in producing tides?

_____ sun, moon

- b) Why? _____

2. Which side of the earth is facing the moon? _____ 1, 2, 3, 4

3. Which sides of the earth are having high tide? _____ 1, 2, 3, 4

4. Which sides are having low tide? _____ 1, 2, 3, 4

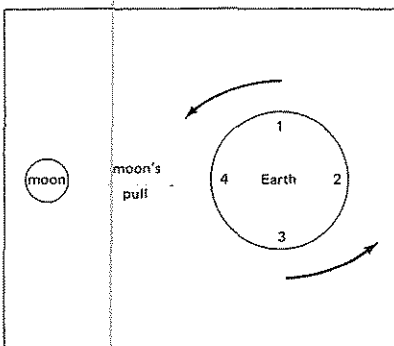


Figure E

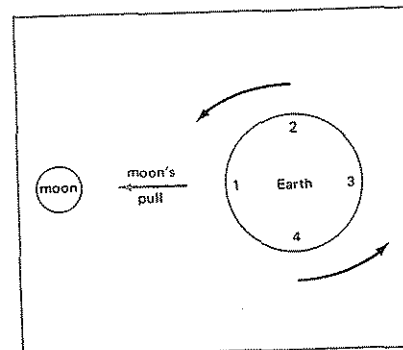


Figure F

The earth rotates. As it rotates, different parts of the earth face the moon. The tides keep changing.

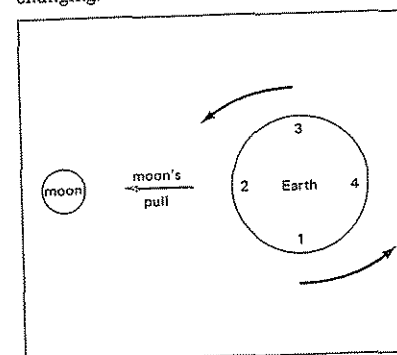


Figure G The earth keeps rotating.

5. a) Which sides have high tide now? _____ 1, 2, 3, 4
- b) Which sides have low tide? _____ 1, 2, 3, 4
6. About how much time has passed between Figures E and F? _____
7. a) Now, which sides have high tide? _____ 1, 2, 3, 4
8. a) About how much time has passed between Figures F and G? _____
- b) About how much time has passed between Figures E and G? _____
9. a) In how many hours will side 2 have high tide again? _____
- b) Which other side will have high tide at the same time? _____
10. a) In how many hours will side 3 have low tide again? _____
- b) Which other side will have low tide at the same time? _____

TWO SPECIAL TIDES

The chief cause of tides is the moon. But the sun also has an effect on tides. Its effect is less. This is because the sun is so far away. Its pull upon the earth is very weak.

The sun's gravity helps produce two special kinds of tides: spring tides and neap tides.

Spring tides happen twice a month—at new moon and at full moon. Spring tides produce high tides that are higher than usual. Spring tides produce low tides that are lower than usual.

Neap tides happen twice a month also but at quarter moons. Neap tides produce moderate tides. That is, tides that are not as high and not as low as usual.

Do the following two exercises. They will help you understand spring and neap tides.

SPRING TIDES

New moon

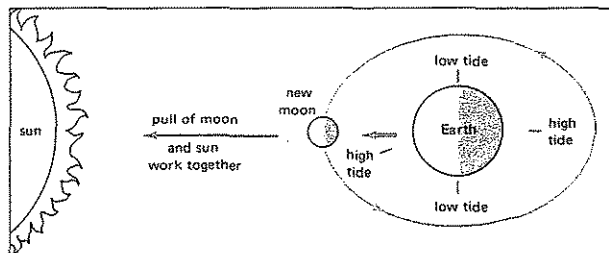


Figure H

Full moon
(about 14 days later)

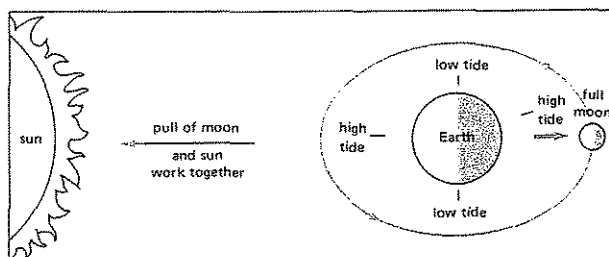


Figure I

- At the new moon and at the full moon, the sun, earth, and moon _____ are, are not in a line.
- When the sun, earth, and moon are in a line, the gravity pull upon the earth becomes _____ stronger, weaker.
- When the sun, earth, and moon are in a line, high tides are _____ higher, lower than usual; low tides are _____ higher, lower than usual.
- a) What do we call unusually high and low tides? _____
b) How often do they happen? _____
- At which moon phases do spring tides take place? _____

NEAP TIDES

Quarter moon

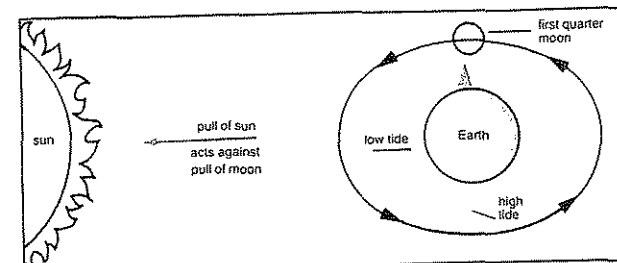


Figure J

Last quarter moon
(about 14 days later)

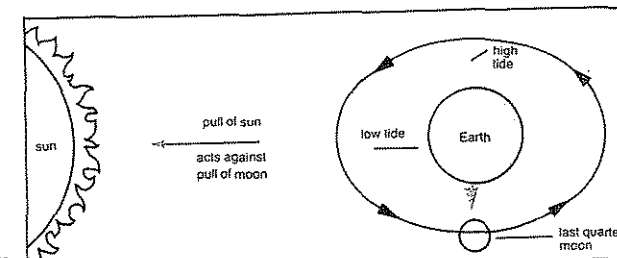
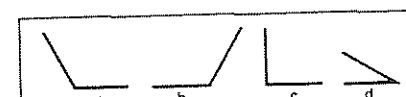
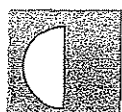
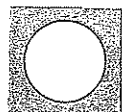
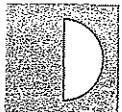
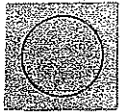


Figure K

- At the quarter moon, the sun, earth, and moon _____ are, are not in a line.
- At quarter moon, the moon and sun are at right angles. Which of the following is a right angle? _____

- When the moon and sun are at right angles, the gravity pull upon the earth becomes _____ stronger, weaker.
- When the moon and sun are at right angles, tides are _____ extra high and extra low, not very high and not very low.
- Tides that are not very high and not very low are _____ extreme, moderate tides.
- a) What do we call moderate tides? _____
b) How often do they happen? _____
- At which moon phases do neap tides take place? _____
- By the way, what do we call extreme tides? _____

WHICH PHASE?

Name the phases of the moon below each picture.



1. _____ 2. _____ 3. _____ 4. _____

Six events are listed below. Name the phases at which each takes place.

5. Sun, earth, and moon are in a line _____
6. Sun, earth, and moon form a right angle _____
7. Extra high and extra low tides _____
8. Moderate tides _____
9. Spring tides _____
10. Neap tides _____

THROW ONE OUT

In each of the following sets of terms, one of the terms does not belong. Circle that term.

1. sun moon chief cause of tides
2. tides follow the earth's rotation follow the moon's rotation
3. time between tides 12 hours and 6 minutes 6 hours and 12 minutes
4. spring tides at full moon and new moon at quarter moons
5. neap tides at quarter moons at full moon and new moon

WHY DO HEAVENLY BODIES KEEP MOVING?

10-3 40	
	inertia: the tendency of a body to stay at rest unless moved or keep moving unless stopped

AIM | Why do heavenly bodies 23 keep moving?

Every heavenly body is moving. And each one keeps on moving. It doesn't stop. The moon moves around the earth. The earth and the other planets move around the sun. The sun itself is moving. So are all the stars and galaxies.

Why do heavenly bodies keep moving?

The movements of heavenly bodies can be explained by what scientists call *inertia*. There is a scientific statement or "law" called the *Law of Inertia*. It states that:

1. A body that is at rest (not moving) will stay at rest unless some force acts upon it.
2. A body that is moving will keep moving unless some force acts upon it.

In short, inertia means that every object will try to stay the way it is—either moving or at rest.

Every object has inertia. You experience inertia in many ways. For example, when the car you are moving in stops quickly, you keep moving. That's why seat belts were invented.

On earth, air resistance and gravity slow down moving objects. But there is no air in outer space. And the gravitational attraction between all heavenly bodies is balanced. There is very little to slow or stop them. They just keep moving.

- The moon keeps moving around the earth.
- The planets keep moving around the sun.
- The galaxies keep moving through space.

EXPERIENCES WITH INERTIA

Look at Figure A. Then answer the questions or fill in the blanks.

1. Will this swing move by itself?

2. What will make the swing move?

3. State the part of the Law of Inertia that explains why the swing does not move by itself. _____

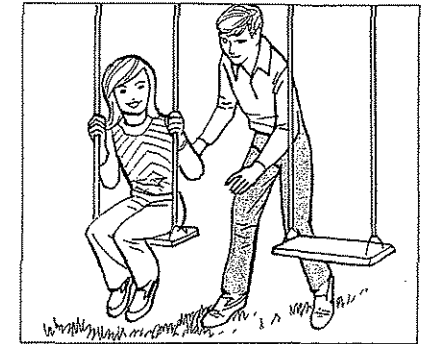


Figure A

The "author" of the Law of Inertia was Sir Isaac Newton (1642–1727). He was the same scientist who first explained gravity.

4. In which direction does gravity pull? _____
Underline the correct answer.
5. What effect does the force of gravity have on a moving object?
 - a) It speeds it up.
 - b) It slows it down.



Figure B

Safety devices like seat belts and straps are placed in many cars by law. They are very important. They help protect us from injury.

6. In which direction do seat belts and straps keep you from moving?

7. Seat belts and straps are important at *all* speeds. But at which speeds are they *most* important? _____

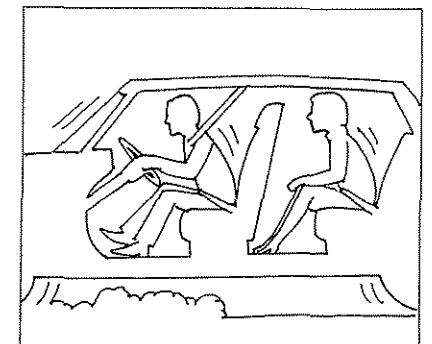


Figure C

COMPLETING SENTENCES

Complete the sentences with the choices below. Three of these may be used twice.

keep moving
balanced
Law of Inertia

air resistance
stay at rest
Sir Isaac Newton

force
gravity

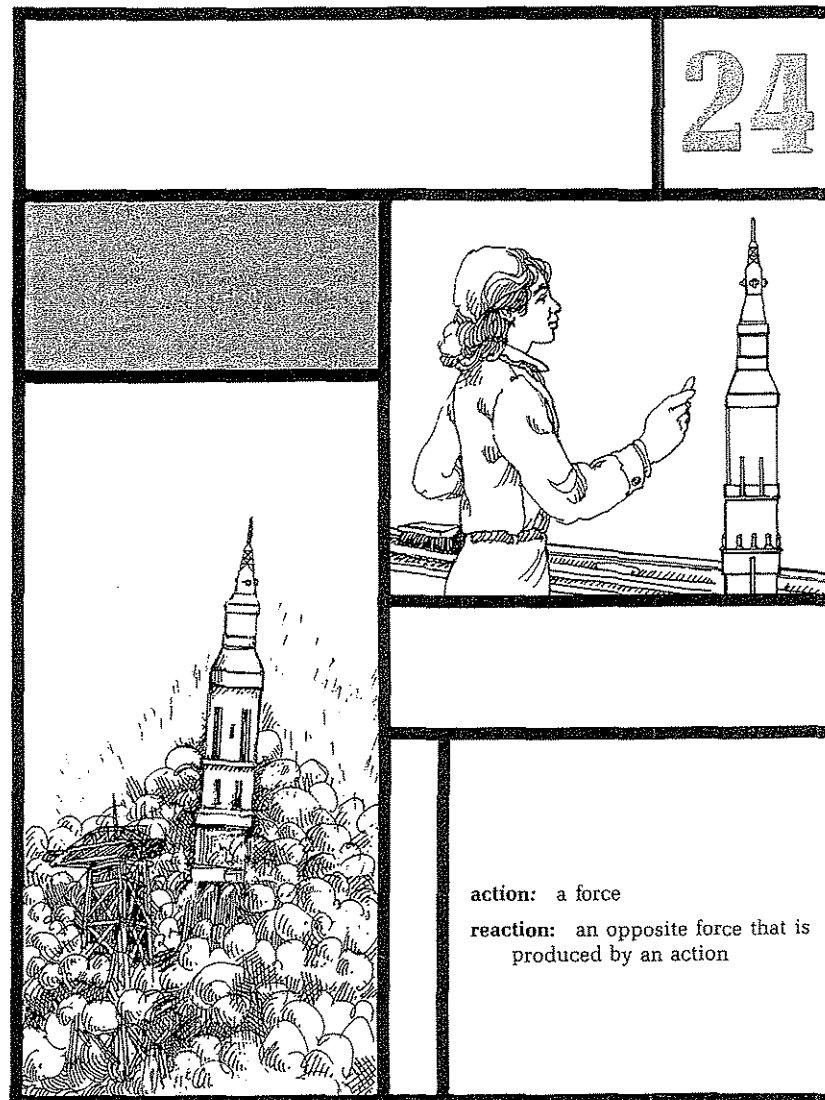
1. An object at rest tends to _____.
2. An object that is moving tends to _____.
3. An object at rest will move only if a _____ acts upon it.
4. A moving object will stop moving if a _____ acts upon it.
5. The scientific statement that explains why objects move or stay still is called the _____.
6. The author of the Law of Inertia was _____.
7. On earth, moving objects are slowed by _____ and _____.
8. In outer space, there is no _____.
9. The gravities of all heavenly bodies are _____.
10. Inertia explains why heavenly bodies _____.

IN YOUR OWN WORDS, PLEASE

1. State the Law of Inertia. _____
2. What effect does inertia have on heavenly bodies? _____

WHAT CAUSES A ROCKET TO MOVE THROUGH SPACE?

24



action: a force

reaction: an opposite force that is produced by an action

AIM | What causes a rocket to 24 move through space?

Did you ever blow up a balloon and let go suddenly? What happened? It flew through the air. It zigzagged a bit. But generally, it flew in the direction opposite to the mouthpiece.

The balloon acted like a small rocket. It moved forward as the air was escaping from the mouthpiece.

Huge rockets have lifted astronauts into space. Smaller rockets have placed satellites into orbit around the earth. Large or small, all rockets work on the same idea—even your balloon “rocket.”

What is this idea?

You remember Sir Isaac Newton, of course! He explained gravity and inertia. Newton also helped explain how a rocket moves. It is explained in Newton's Third Law of Motion. This law says that every time there is a force acting upon an object in one direction there is an equally strong force acting in the opposite direction.

- The first force is called the action.
- The opposite force is called the reaction.

The scientific way to state Newton's Third Law of Motion is:

For every action, there is an equal reaction
in the opposite direction.

In a rocket, the action pushes *downward*. This force comes from fuel burning in the rocket's engines. You have probably seen films of flames shooting downward during a blastoff. As the hot gases move downward, the rocket moves upward into the sky. . . . And away we go!

UNDERSTANDING WHY ROCKETS MOVE

A balloon can move like a rocket. Figures A and B show two blown-up balloons.

- The mouthpiece of the balloon in Figure A is closed.
- The mouthpiece of the balloon in Figure B has just been opened.

Look at the figures.

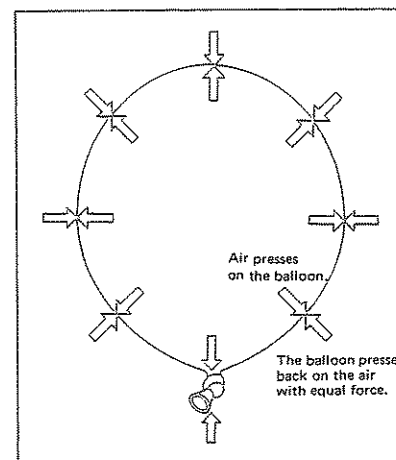


Figure A

Answer these questions about the balloon in Figure A.

1. The forces _____ are, are not balanced.
2. The balloon _____ will, will not move forward.
3. Does a closed blown-up balloon move like a rocket? _____

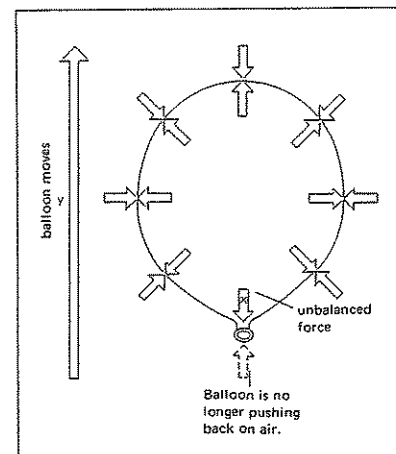


Figure B

Answer these questions about the balloon in Figure B.

4. The forces are _____ still, no longer balanced.
5. Some air is escaping from _____
x, y
6. As the air escapes, it causes the balloon to move in the direction of arrow _____
x, y

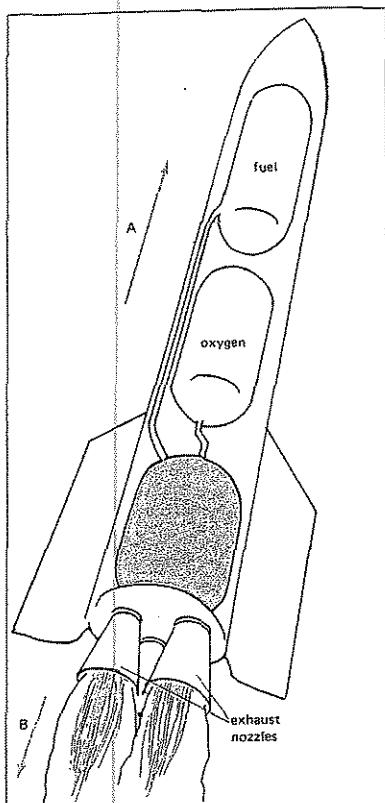


Figure C

Figure C shows a space rocket. Study Figure C. Answer the questions.

7. A rocket carries fuel. What else does a rocket carry? _____

Oxygen helps the fuel to burn.

8. a) Does an airplane carry its own oxygen? _____
b) Why does a rocket carry its own oxygen? _____

9. Hot gases escape through the _____.

10. Arrow _____ A, B stands for the action.

11. Arrow _____ A, B stands for the reaction.

12. The rocket moves towards _____.

A, B

MATCHING Match the two lists. Write the correct letter on the line next to each number.

1. _____ an action
2. _____ opposite
3. _____ fuel
4. _____ oxygen
5. _____ Sir Isaac Newton

- a) how actions and reactions are related
- b) needed for a fuel to burn
- c) causes a reaction
- d) Third Law of Motion
- e) burns

YOU'VE COME A LONG WAY, BABY!

The ancient Chinese actually invented rockets when they shot fire-crackers into the air.

Now, the Saturn V rocket is America's most powerful rocket. This rocket took our astronauts to the moon.

Here are some interesting facts about the Saturn V:

- ▢ The Saturn V stands 111 meters (364 feet) tall. This is 18 meters (59 feet) taller than the Statue of Liberty.
- ▢ At lift-off, it uses 13.6 metric tons (15 tons) of fuel every second. This is enough fuel to run a family car for nearly 5 years.
- ▢ Its lift-off weight is 2,721,554 kilograms (about 6,000,000 pounds). This is equal to the weight of 20 loaded airliners—or 1,818 medium-sized cars.

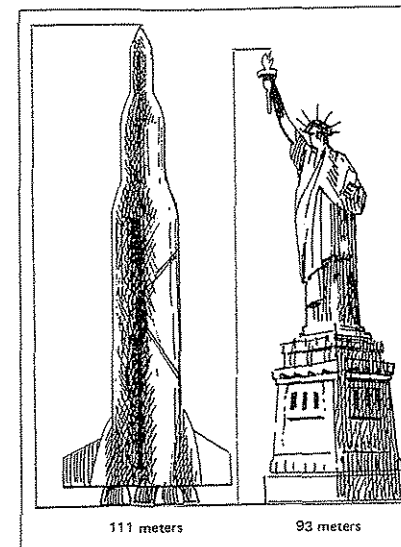


Figure D

EXPERIENCES WITH ACTIONS AND REACTIONS

Look at Figures E through H. Each figure shows an action and a reaction.

Identify the action and reaction in each picture. Answer by letter.

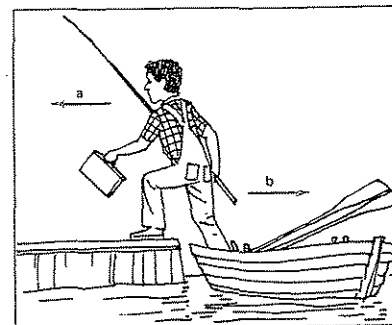


Figure E

1. Action _____
Reaction _____

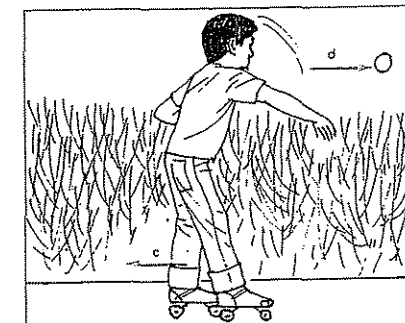


Figure F

2. Action _____
Reaction _____

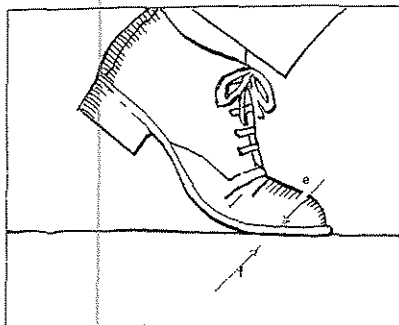


Figure G

3. Action _____
Reaction _____

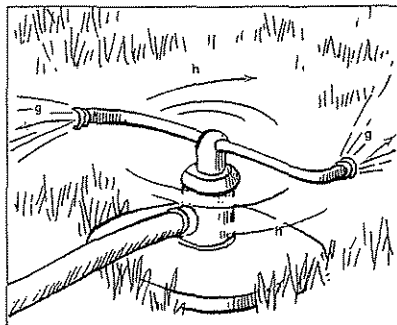


Figure H

4. Action _____
Reaction _____

COMPLETING SENTENCES Complete the sentences with the choices below.

Saturn V
fuel
action
left

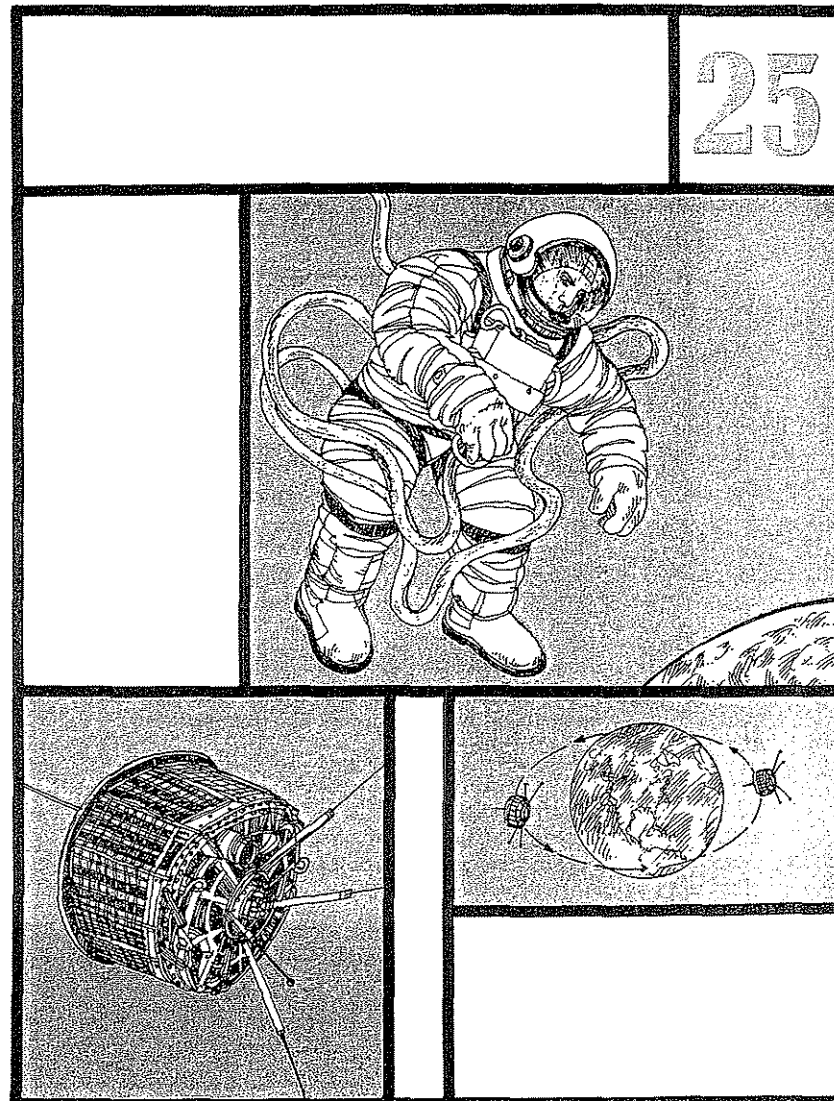
Chinese
down
reaction

Sir Isaac Newton
opposite
oxygen

1. The scientist who stated the Third Law of Motion was _____.
2. Newton's Third Law of Motion states that every _____ has an equal _____.
3. Actions and reactions are _____ in direction.
4. If the direction of an action is *up*, then the direction of a reaction is _____.
5. If the direction of an action is to the *right*, then the direction of a reaction is to the _____.
6. Space rockets carry _____ and _____.
7. Rockets were invented by the _____.
8. America's most powerful rocket is the _____.

HOW DOES A SATELLITE GO INTO ORBIT?

25



AIM | How does a satellite go into orbit?

25 | orbit?

Ten, nine, eight, seven, six, five, four, three, two, one—BLAST OFF! The engines roar like thunder. Flames shoot out from the nozzles. The rocket lifts from its pad. It rises slowly at first. But it gains speed every moment. Soon, the rocket is out of sight. In just twelve minutes it will have placed a satellite into orbit.

How does a satellite go into orbit?

A satellite will go into orbit around the earth

IF it is moving fast enough, and,

IF it is moving parallel to the ground.

To orbit the earth, a satellite must travel at least 28,000 kilometers (17,000 miles) per hour. At this speed, the satellite will circle the earth about 482 kilometers (300 miles) high. If the speed is slower, the satellite will not orbit. It will fall back toward earth.

Why does a satellite stay in orbit? Many people think that a satellite "escapes" the earth's gravity. This is not true. If the earth's gravity did not pull upon a satellite, it would leave the earth completely. It would move into outer space.

It is not only speed that keeps a satellite in orbit. It is also the earth's gravity. Actually, a satellite is always falling. (Surprised?) If the earth were flat, a satellite would surely plunge back towards the ground. But the earth is not flat. The earth is round. Its surface curves.

A satellite drops. But so does the curve of the earth. The earth curves downward the same distance as a satellite drops. For this reason, an orbiting satellite does not lose height. It just keeps orbiting the earth. It is like a falling object that can't land because the floor keeps moving downward.

UNDERSTANDING WHY A SATELLITE ORBITS

Study Figures A and B. Then answer the questions or fill in the blanks.

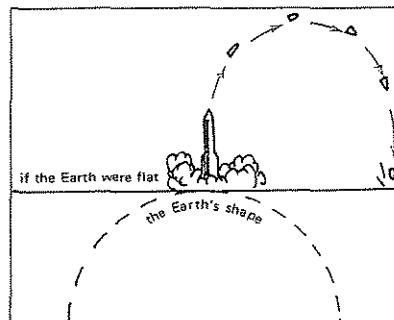


Figure A

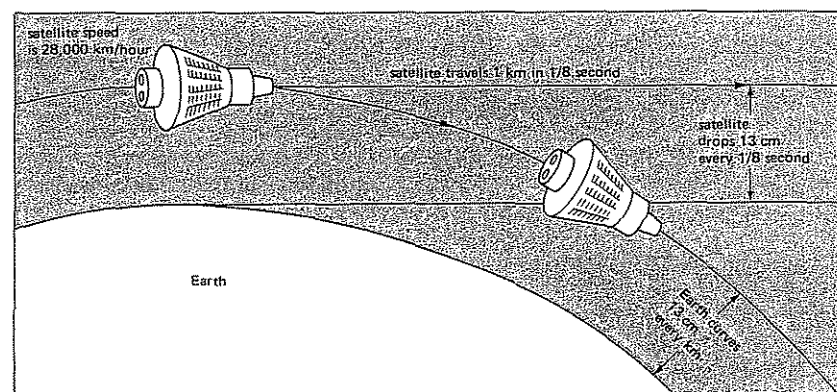


Figure B

1. A satellite in orbit is always _____
rising, falling
2. Name the force that pulls a satellite downward. _____
3. Could we orbit a satellite if the earth were flat? _____
4. Does a flat surface curve? _____

5. The earth is shaped like a sphere. Does a sphere curve? _____
6. How much does the curve of the earth drop every kilometer? _____ cm
7. A satellite travels 28,000 kilometers every hour. This is the same as one kilometer every _____ second.
8. In $\frac{1}{8}$ second the satellite travels _____ km.
9. In $\frac{1}{8}$ second the satellite drops _____ cm.
10. In the same amount of time it takes the satellite to travel 1 km ($\frac{1}{8}$ second), the curve of the earth drops _____ cm.

11. The distance a satellite drops compared to the distance the earth's curvature drops is _____. (Look at your answers to questions 9 and 10.)
the same. different
12. a) After moving $\frac{1}{2}$ second, is the satellite any closer to the earth's surface?

- b) Is it any closer after 8 seconds? _____
- c) Is it any closer after 8 minutes? _____
- d) What about 8 days? Will it be any closer then? _____
13. In your own words, explain why a satellite stays in orbit. A satellite stays in orbit because _____

UNDERSTANDING SATELLITE SPEEDS AND ORBIT SHAPES

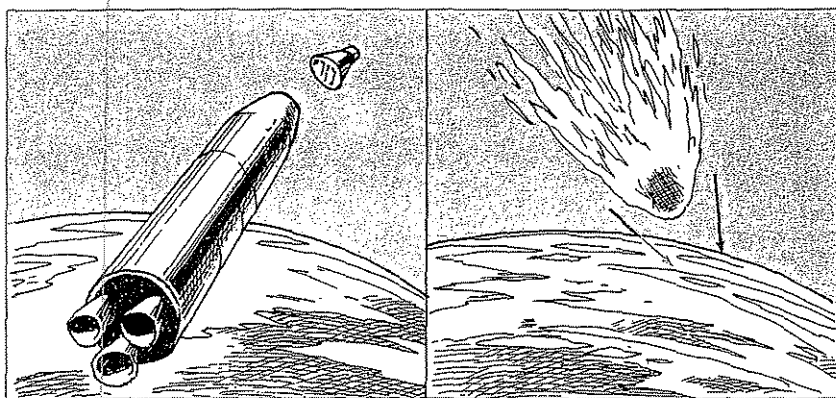


Figure C

Rockets launch satellites into orbit.

If the speed is *slower* than 28,000 kilometers per hour, the satellite will not orbit.

1. What will happen to the satellite? _____

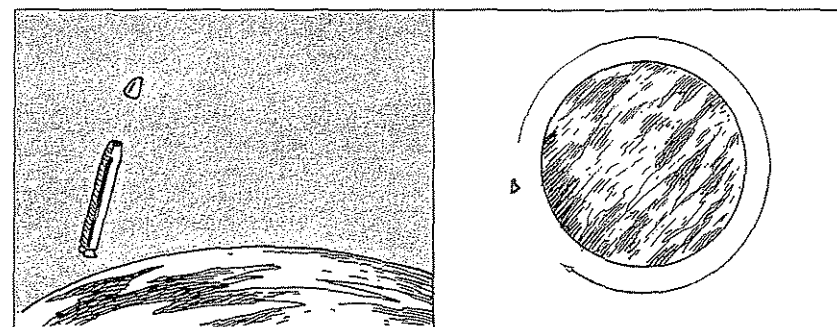


Figure D

If the speed is *exactly* 28,000 kilometers per hour, the satellite will orbit the earth in a perfect circle about 482 kilometers high.

2. The distance from the earth to a satellite in a circular orbit _____ does, does not
change during the orbit.

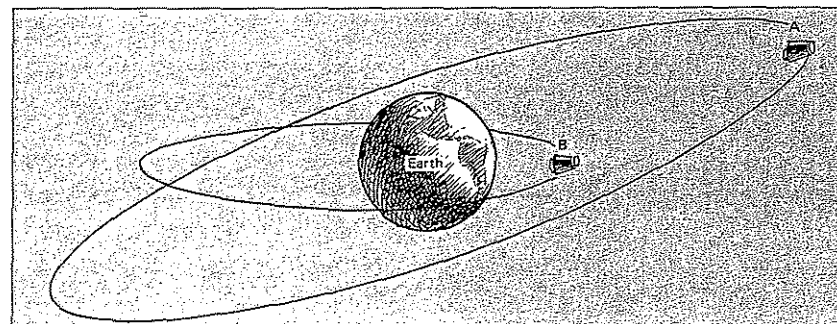


Figure E

If the speed is *faster* than 28,000 kilometers per hour (but less than 40,233 kilometers per hour), the orbit will be the shape of an *ellipse*. (Remember ellipses?) The faster the speed, the longer the ellipse.

3. The distance from the earth to a satellite in an elliptical orbit _____ does, does not
change during the orbit.
4. A and B are the orbits of two different satellites.
- a) Which one was launched with a faster speed? _____
- b) How do you know? _____

(What's so special about 40,233 kilometers per hour? You will find out in the next Aim.)

THE AGE OF SPACECRAFT

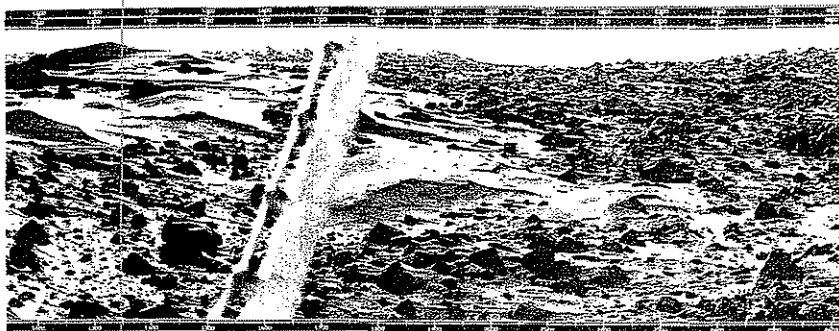


Figure F A photo of the planet Mars taken by a Mariner spacecraft

America's first successful satellite was Explorer 1. It was launched in 1958.

Since the early days of space flights, many satellites have gone into orbit. Some satellites have even orbited around other planets.

Mariner spacecraft have been made to orbit several planets.

We can get a better understanding of what the other planets are like from the photographs and instrument readings taken from this spacecraft.

Not only have satellites orbited around the earth, but space stations have orbited as well. A space station is larger than a satellite. It carries many instruments for research. But it also has living quarters for people.



Figure G A model of a space station

Both America's Skylab and the Soviet Salyut projects have shown that people can work and live in space for long periods of time.

TRUE OR FALSE Write T on the line next to the number if the sentence is true.
FALSE Write F if the sentence is false.

1. _____ All satellites are artificial.
2. _____ The earth is a satellite.
3. _____ The earth is a satellite of the moon.
4. _____ To go into orbit, a satellite must travel at least 28,000 miles per hour. (Careful!)
5. _____ A satellite must move parallel to the ground.
6. _____ Every satellite moves in a circular orbit.
7. _____ A satellite traveling at 28,000 km/h moves in a circular orbit.
8. _____ A satellite traveling slower than 28,000 km/h moves in an elliptical orbit.
9. _____ A satellite is always falling.
10. _____ The earth curves downward less than the distance a satellite drops.

WORD SEARCH The words in this list are hidden in the groups of letters. Try to find each word. Draw a line around each word. The spelling may go in any direction: up-and-down, across, or diagonally.

SATELLITE
ELLIPSE
ORBIT
CURVE
SPACE
SPHERE
EARTH
SPEED

A	H	T	R	A	E	L	E	T
S	A	T	E	L	L	I	T	E
P	P	B	U	E	L	T	I	V
A	T	H	C	A	I	E	B	R
C	T	A	E	A	P	V	R	U
C	P	E	D	R	S	O	O	C
S	A	T	D	E	E	P	S	M

COMPLETING SENTENCES

Complete the sentences with the choices below.

falling
curves
an ellipse
28,000

downward
artificial satellites
a circle
sphere

parallel
orbit
gravity
drops

1. Rockets send _____ into orbit.
2. For a satellite to orbit the earth, its speed must reach at least _____ kilometers per hour. The satellite must also move _____ to the ground.
3. A satellite is always _____.
4. A satellite keeps falling because _____ pulls upon it.
5. The earth is shaped like a _____. A sphere _____.
6. The earth curves _____ the same distance as a satellite _____.
7. A satellite blasts off. Its speed is slower than 28,000 kilometers per hour. The satellite does not go into _____.
8. A satellite is in orbit. It is moving exactly 28,000 kilometers per hour, about 482 kilometers high. The shape of its orbit is _____.
9. A satellite is in orbit. It is moving faster than 28,000 kilometers per hour, but slower than 40,233 kilometers per hour. The shape of its orbit is _____.

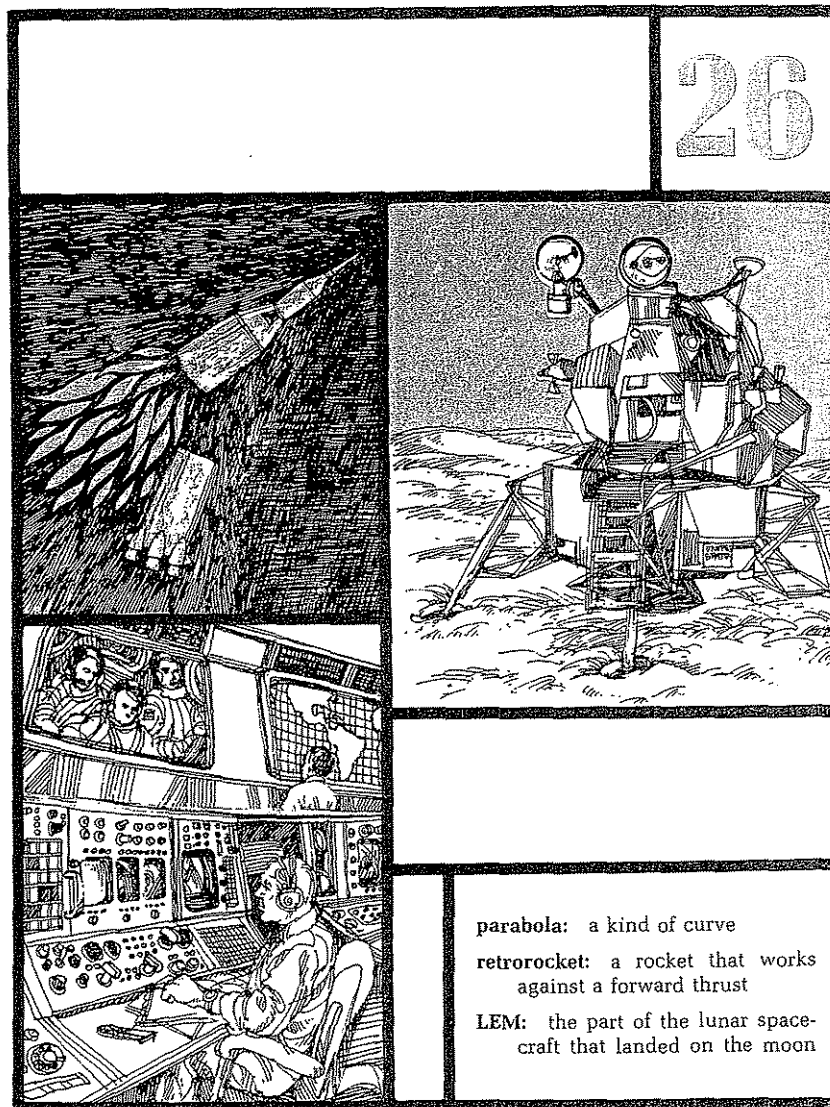
REACHING OUT

An artificial satellite does not orbit forever. It slows down—a tiny bit at a time. Finally, it leaves its orbit and plunges towards earth. It usually burns up in the atmosphere.

What causes a satellite to slow down? _____

HOW DOES A SPACECRAFT REACH THE MOON?

26



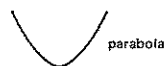
AIM | How does a spacecraft 26 | reach the moon?

The higher an object is from the earth, the less the earth's gravity pulls upon it. For a spacecraft to reach the moon, it must "escape" the earth's gravity. This does not mean that the earth's gravity does not pull upon the spacecraft. It means that the earth's gravity is not strong enough to pull the spacecraft back to earth.

The speed needed for a spacecraft to escape the earth's gravity is 40,233 kilometers (25,000 miles) per hour. This speed is called the escape velocity.

A spacecraft traveling at escape velocity, does not move in an ellipse. It travels along a curve called a *parabola*. A parabola is shaped like a wide letter U. This is what a parabola looks like:

Notice that the legs keep moving farther apart. They never meet.



A spacecraft moving at escape velocity keeps moving into space. If its speed is not changed, it is "captured" by the sun's gravity. The spacecraft then becomes a satellite of the sun. It orbits the sun just like the planets.

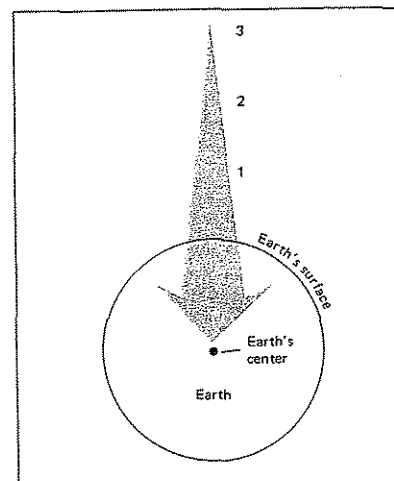
To reach the moon, a spacecraft must be slowed. Slowing a spacecraft also changes its direction. Small retrorockets on the spacecraft are fired for an exact number of seconds. This slows the spacecraft just enough for a "bull's-eye" to the moon.

A computer figures out just how long the retrorockets must fire.

A spacecraft that comes near the moon at the correct speed and angle will orbit the moon. A spacecraft, as you know, can be slowed enough to land on the moon.

UNDERSTANDING GRAVITY AND ESCAPE VELOCITY

Study Figure A. Then answer the questions or fill in the blanks.



The arrow stands for the earth's gravity.

1, 2, and 3 stand for points above the earth's surface.

Figure A

1. The earth's gravity is strongest at its _____
surface, center
2. At which point above the ground is the earth's gravity the strongest? _____
1, 2, 3
3. From point 1 to point 2, the earth's gravity becomes _____
stronger, weaker
4. From point 2 to point 3, the earth's gravity becomes _____
stronger, even weaker
5. At which point does the earth's gravity seem to be zero? _____
(Remember, it never really is zero!)
6. a) Which point must a spacecraft pass in order to "escape" the earth's gravity?

- b) How fast must the spacecraft travel to reach this point? (Write your answer in kilometers.) _____
- c) What is this speed called? _____
7. Motors do not keep a spacecraft moving after it escapes the earth's gravity.
What keeps the spacecraft moving? (Hint: Check back to Aim 23.) _____

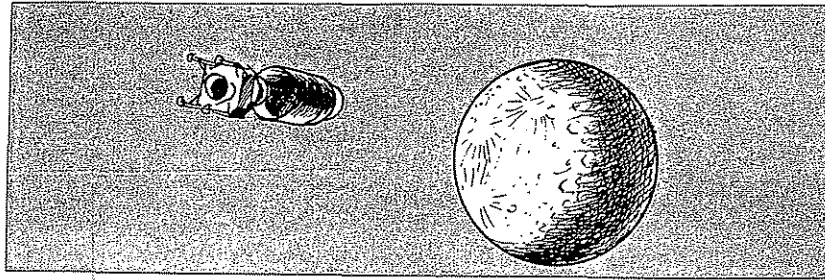


Figure B

8. A spacecraft on its way to the moon "coasts" most of the way. Inertia keeps it moving. As it coasts, the spacecraft slowly loses speed. When it is about 80,000 kilometers (50,000 miles) from the moon, it starts to pick up speed by *itself*. No motors help it.

What causes the spacecraft to pick up speed?

LANDING ON THE MOON

ENTERING LUNAR ORBIT

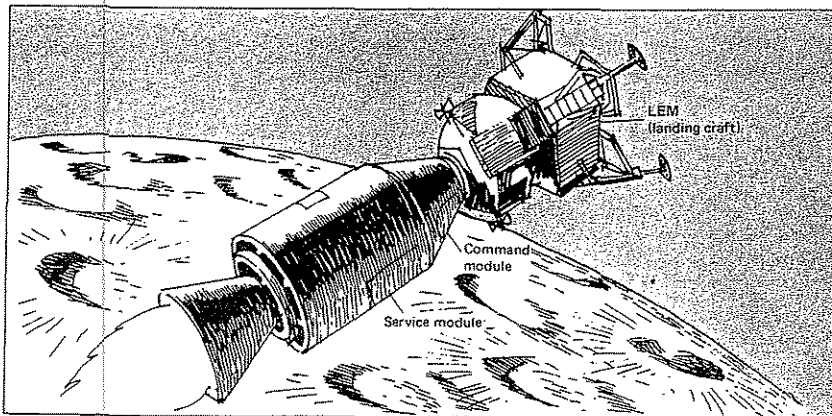


Figure C

1. A retrorocket in the service module fires. The spacecraft goes into lunar orbit. Three astronauts are in the command module.

TRANSFER

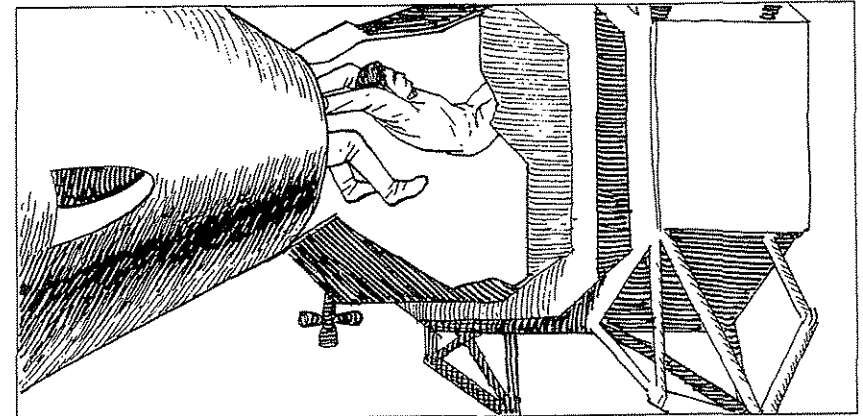


Figure D

2. During the orbit, two of the astronauts transfer into the LEM—the Lunar Excursion Module.

The third astronaut stays behind in the command module. He does not land on the moon.

SEPARATION

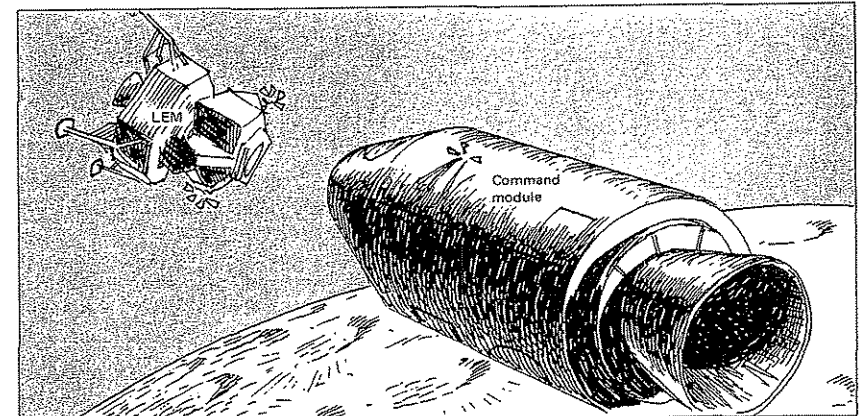


Figure E

3. The LEM separates from the command module.

LANDING

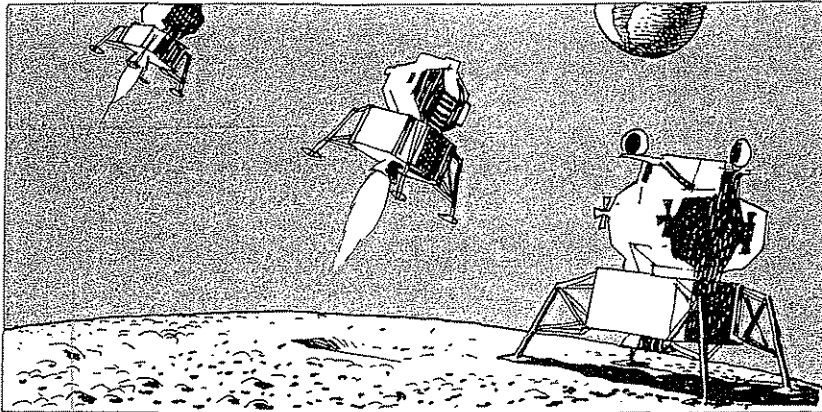


Figure F

4. The LEM's descent engine fires. The LEM lowers gently onto the moon's surface.

HOW ROCKETS ARE DESIGNED

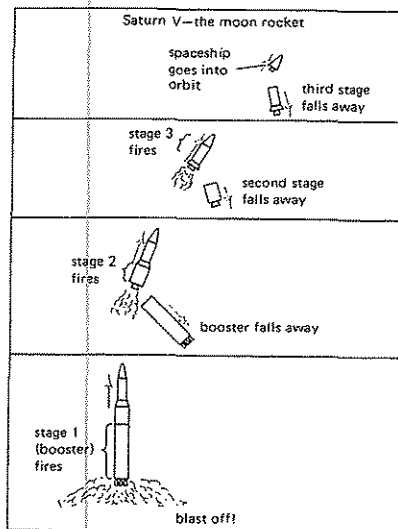


Figure G

Tremendous power and speed are needed to send a spacecraft or satellite into space. So far, no single rocket can do the job.

A space rocket looks like a single rocket. But it is not. It is more than one rocket. Each rocket is called a stage.

The Saturn V rocket is a three-stage rocket. Each stage fires separately.

- ▣ The main rocket (the first stage) is called the *booster rocket*. The booster rocket fires first. It separates from the other two stages after its fuel is used up.
- ▣ The second stage fires next. It too falls away after its fuel is used up.
- ▣ The third stage fires last. It separates from the spaceship after the spaceship is in orbit.

Study Figure G. Answer these questions or fill in the blanks.

1. The rocket is heaviest _____ at takeoff, after the stages separate.
2. Gravity pulls upon the rocket most strongly when the rocket is _____ on, high above the ground.
3. The most powerful rocket is the _____ stage.
first, second, third
4. What is the first stage called? _____
5. List two reasons why the booster is the most powerful stage.

6. The rocket becomes lighter as the booster is firing. Why? _____

7. The booster falls away when the stage _____ fires.
8. When the booster falls away, the rocket becomes _____ heavier, even lighter.
9. The second stage falls away when the stage _____ fires.
10. What happens to the weight of the rocket after the second stage falls away?

11. The third stage is the least powerful rocket. List two reasons why a less powerful rocket is needed? _____

12. When does the third stage fall away? _____

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|--------------------------|-----------------------|
| 1. _____ ellipse | a) legs never meet |
| 2. _____ parabola | b) slow a spacecraft |
| 3. _____ retrorockets | c) three-stage rocket |
| 4. _____ escape velocity | d) closed curve |
| 5. _____ Saturn V | e) overcomes gravity |

COMPLETING SENTENCES Complete the sentences with the choices below.

escape velocity
escape
40,233

stronger
close

28,000
less

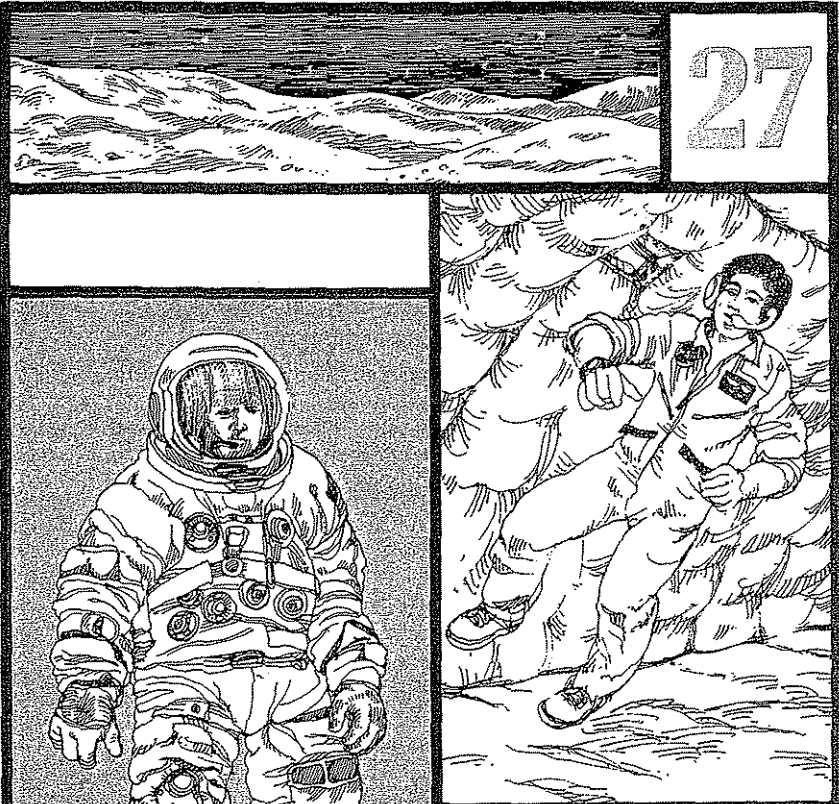
1. The speed a satellite needs to orbit the earth is about _____ km/h.
2. The speed a spacecraft needs to go to the moon or another planet is _____ km/h.
3. For a spacecraft to go to the moon or another planet, it must _____ the earth's gravity.
4. About 80,000 kilometers from the moon, the pull from the moon is _____ than the pull from the earth.
5. You feel the earth's gravity most when you are _____ to earth.
6. As you move away from earth, you feel its gravity _____.
7. The speed an object needs to leave the gravity of a space body is called its _____.

WORD SCRAMBLE Unscramble each of the following to form a word or term that you have read in this Aim.

1. TROCEK _____
2. SPACEE TIVOCELY _____
3. ROOSTEB _____
4. APOLARBA _____

HOW DO WE SOLVE THE PROBLEMS OF LIVING IN SPACE?

27



simulator: something that copies

umbilical cord: a tube that carries important materials

AIM | How do we solve the 27 | problems of living in space?

Everything that surrounds an organism is called its environment. Air and water are parts of the environment. So are the temperature, air pressure, and food.

Our environment is well suited for life. We have air to breathe, food to eat, and water to drink. The air pressure is just right. In most places the temperature is never too hot or too cold. The atmosphere blocks out harmful radiation. In short, we live in a "friendly" environment.

The environment in space, however, is not friendly to humans. It presents many problems. You could not live in space the same way that you live on earth. There is no air to breathe. There is also no air pressure. The temperature is either much too hot or much too cold. No food grows in space. And there is nothing to block out harmful radiation.

There are other problems too. Living things produce wastes. The wastes must be eliminated. On earth, we have no problem eliminating our wastes. Every time we breathe out we release carbon dioxide into the air. Heat and moisture from our skin goes into the air, too. We use water to flush away the liquid and solid wastes we produce.

In space, getting rid of wastes is not so easy. In fact, just keeping clean is a problem.

On earth, gravity holds you to the ground. In a moving spacecraft, there is no gravity. Actually, gravity from outer space does pull upon the spacecraft. But the movement of the spacecraft cancels it out. The result is "zero" gravity. In zero gravity a person seems to weigh nothing. Just imagine. You would float around the spacecraft if you didn't hold onto something!

Because of all these problems of living in space, astronauts must bring along their own environment! It must be like the environment found on earth. Special clothing and instruments have been designed so that the traveler in space has everything that is needed to stay alive.

LIVING IN A SPACECRAFT

Look at the figures. Answer the questions.

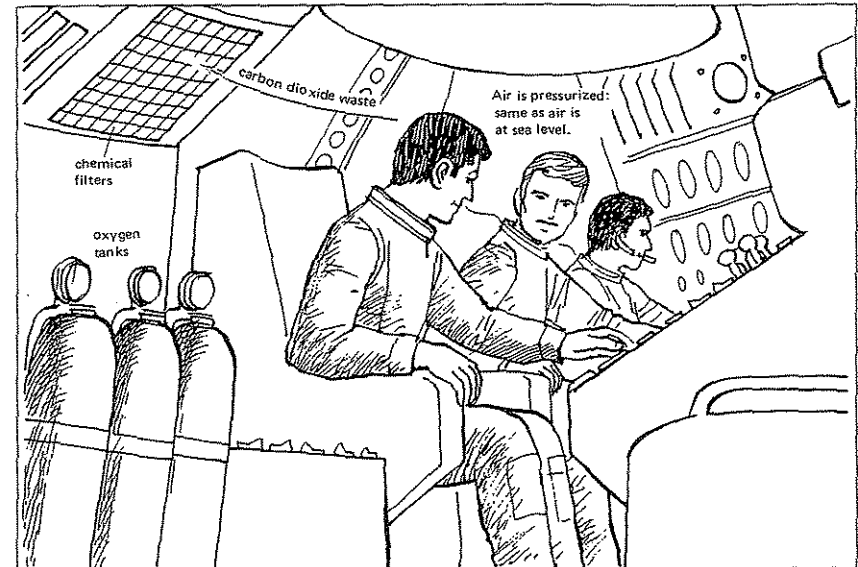


Figure A Inside a spacecraft in flight: like a little part of the earth—far from earth.

Outside the spacecraft the temperature is extremely cold.

1. The temperature inside the spacecraft _____ is, is not _____ extremely cold.

Outside the spacecraft, there is no air pressure.

2. You _____ live where there is no air pressure.
can, cannot

3. The air inside the spacecraft is _____ cold, pressurized _____.

4. The pressure inside the cabin is like the air pressure on earth at _____ sea level, its center _____.

The spacecraft carries tanks of oxygen.

5. We _____ live without oxygen.
can, cannot

6. In a spacecraft, _____ remove carbon dioxide and odors from the air.
oxygen tanks, chemical filters

Eating in Space

Everything in space is weightless. It is not possible to eat a regular meal like you do on earth. The food would float around inside the cabin. An astronaut would have to chase after the meal.

Early astronauts ate soft foods from tubes that looked like toothpaste tubes. The astronauts would squeeze the food right into their mouths.

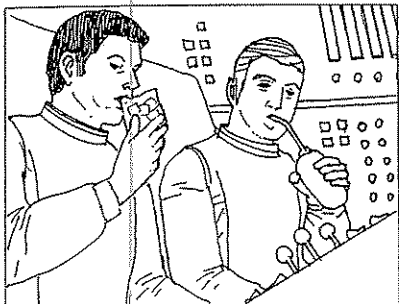


Figure B

Now the food is in bite-sized solid form. It is packed in eatable bags. The astronaut eats the bag along with the food!

It's not like home cooking, but the astronauts say that space food is pretty tasty.

7. What part of a meal must still be squeezed from a tube or bag directly into the mouth? _____

Radiation in Space

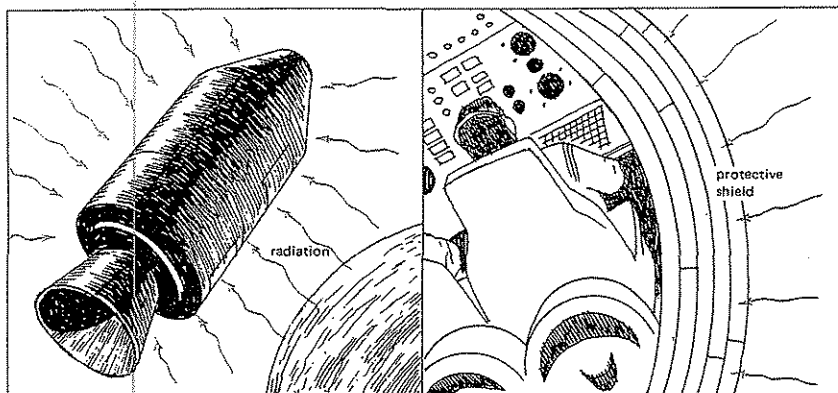


Figure C Several kinds of harmful radiation hit a spacecraft.

8. What keeps the radiation from harming the astronauts? _____

9. What is it on earth that protects us from harmful radiation? _____

Weightlessness in Space



Figure D

Very little can be done about weightlessness. Astronauts prepare themselves for this funny feeling. They train in simulators [SIM yuh lay ters]. In this way an astronaut learns what to expect.

10. Do the astronauts experience the pull of gravity in a moving spacecraft? _____

11. How much do the astronauts seem to weigh there? _____

12. How do astronauts prepare for the feeling of weightlessness? _____

OUTSIDE THE SPACECRAFT

An astronaut may not spend all the time in the spacecraft. Some of the time may be spent taking "space walks" in a pressurized space suit.

An "umbilical cord" connects the astronaut to the spacecraft. It keeps him from floating away.

The cord also carries oxygen to the astronaut and carbon dioxide away so the astronaut can breathe.

Communication wires also pass through the cord.

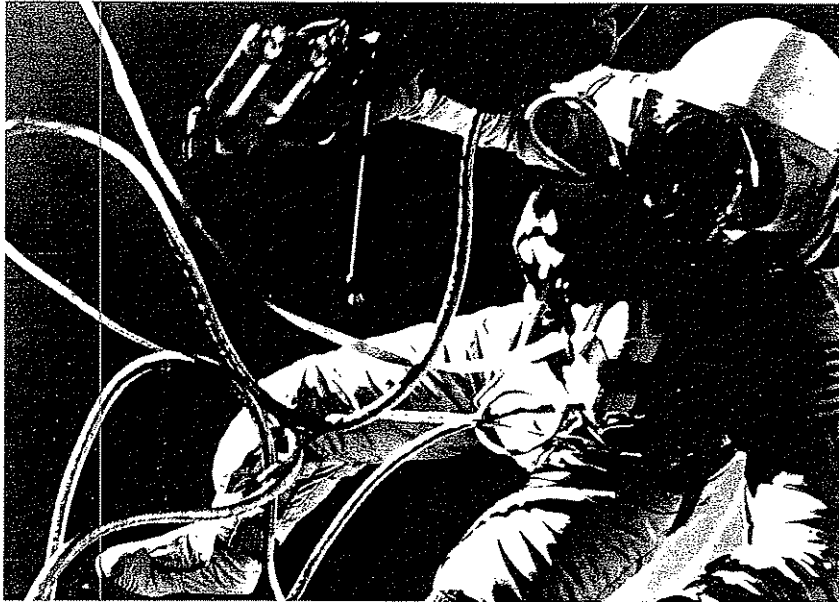


Figure E

1. Is there air pressure outside the spacesuit? _____
2. Is there air pressure *inside* the spacesuit? _____
3. The _____ cord connects the astronaut to the spacecraft.
4. List four reasons why this cord is important.

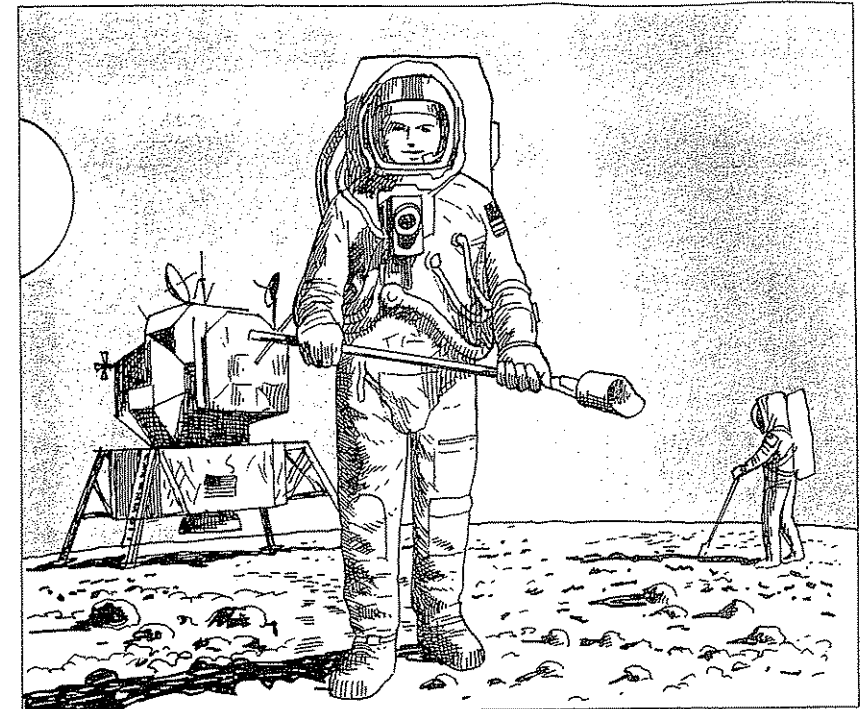


Figure F How would you like to go dancing in a suit like this?

The spacesuit worn on the moon is a very special suit. It provides everything an astronaut needs to stay alive except food and water. We say this spacesuit is self-contained.

MATCHING Match the two lists. Write the correct letter on the line next to the number.

- | | |
|---|------------------------------------|
| 1. _____ carbon dioxide | a) copies zero gravity |
| 2. _____ shields | b) needed for life |
| 3. _____ simulator | c) remove carbon dioxide and odors |
| 4. _____ chemical filters on spacecraft | d) block radiation |
| 5. _____ oxygen | e) waste gas |

COMPLETING Complete the sentences with the choices below.
SENTENCES

like	umbilical cord	temperature
carbon dioxide	radiation	oxygen
simulators	spacecraft	sea level
self-contained	food	

1. A _____ must supply everything an astronaut needs.
2. The environment in a spacecraft must be _____ the environment on earth.
3. The _____ in a spacecraft is kept at a comfortable level.
4. The pressure in a spacecraft is like the pressure on earth at _____.
5. Shielding material is built into spaceships and spacesuits. It protects astronauts from _____.
6. Astronauts train for weightlessness in _____.
7. A space "walker" is connected to the spaceship by an _____.
8. An umbilical cord carries _____ to the astronaut and carries away _____.
9. The spacesuit worn on the moon provides an astronaut with everything except _____.
10. The term that describes the moon space suit is "_____".

REACHING OUT

Spacesuits are white. There is a good reason for this. What is this reason?
